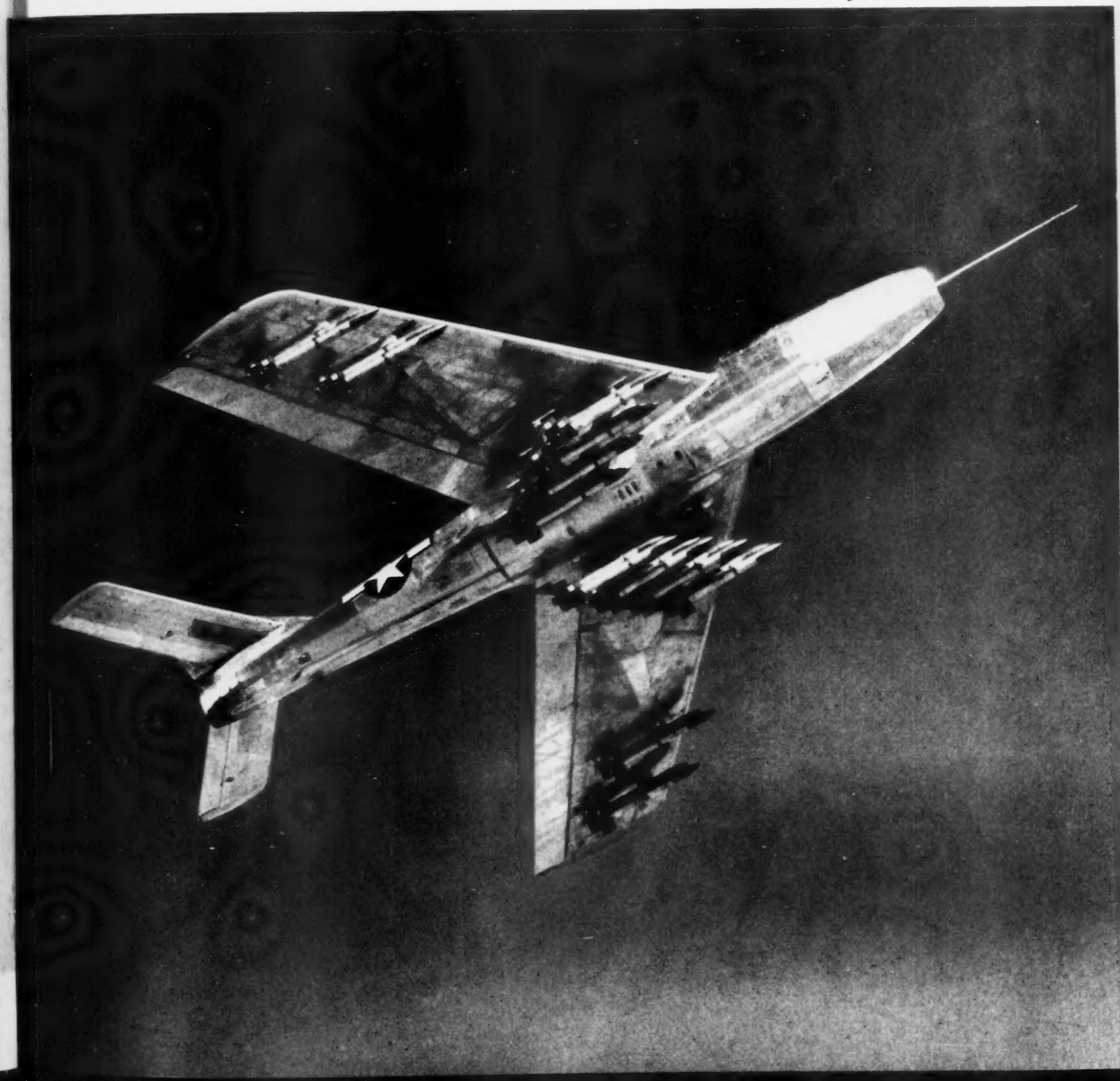
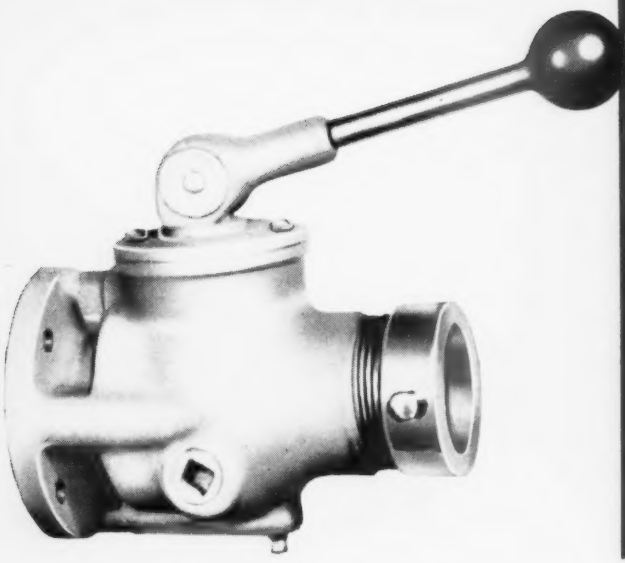
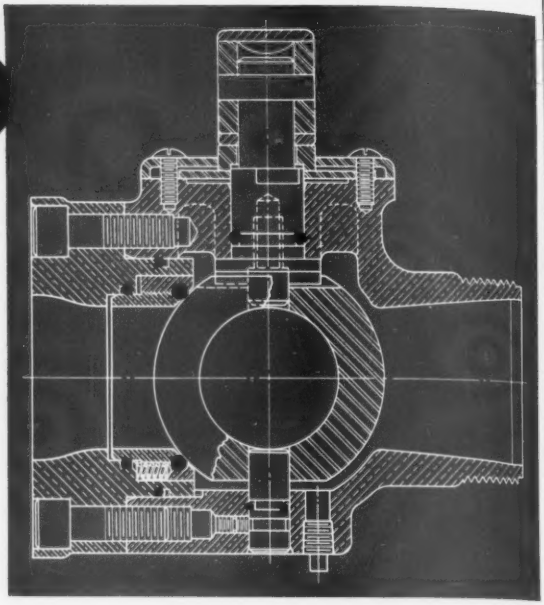
AERONAUTICAL ENGINEERING REVIEW

APRIL 1951







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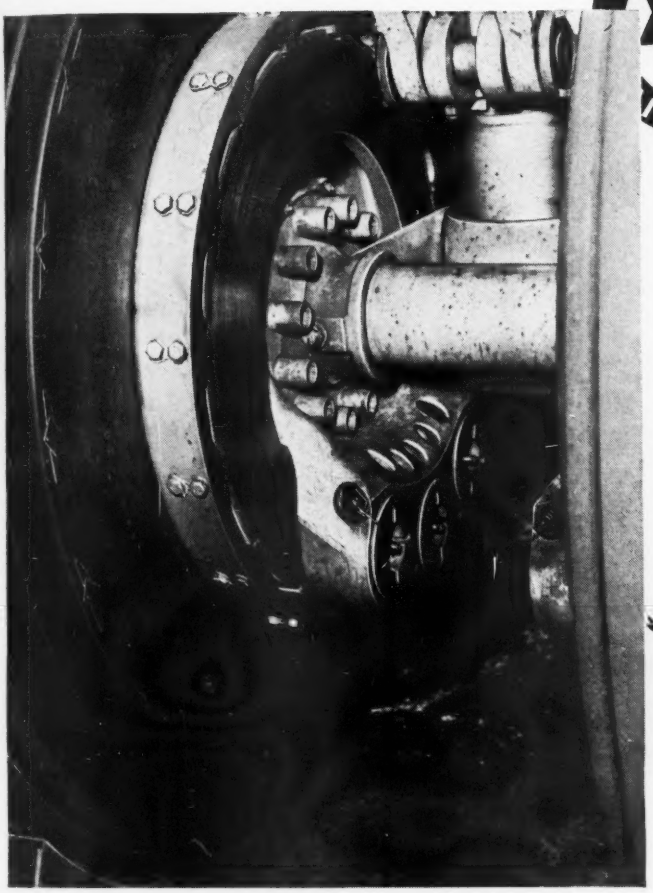

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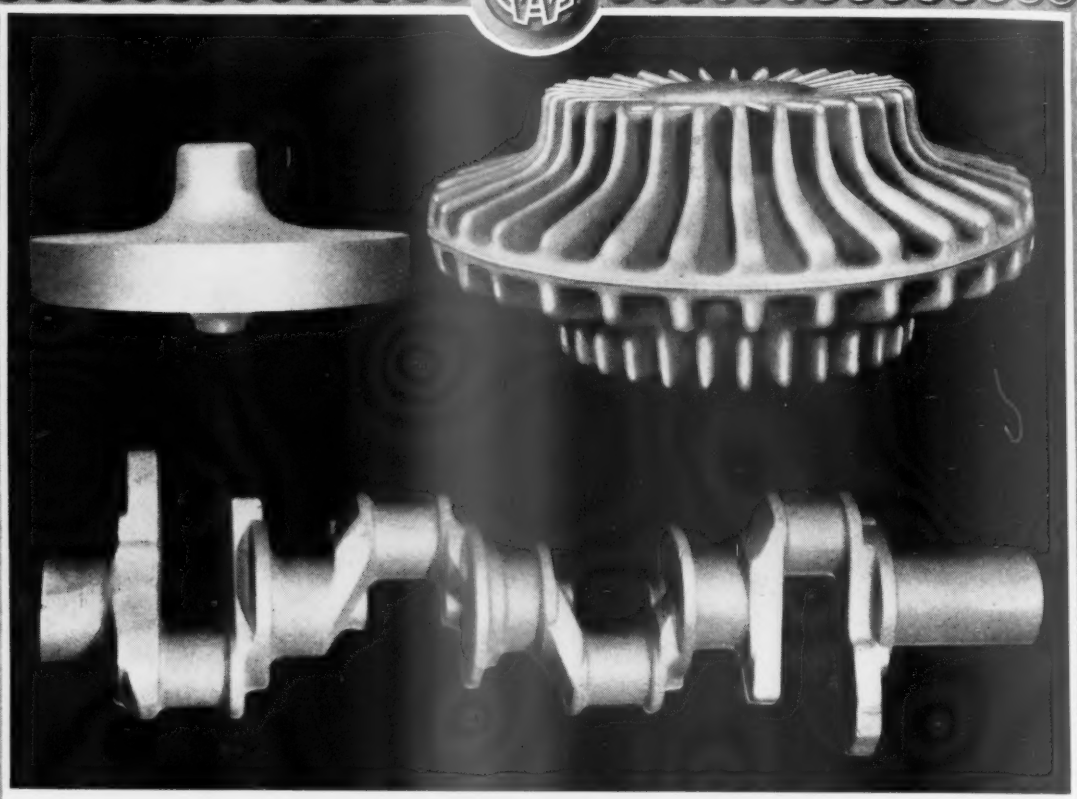

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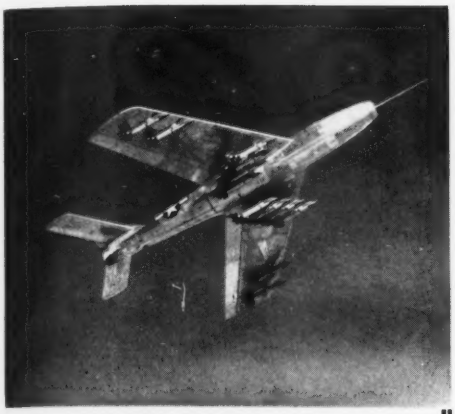

Cover—This first in-flight photo of Republic Aviation Corporation's F-84F Thunderjet shows a sample of the plane's prowess as a ground-support fighter-bomber. Here it is carrying 24 5-in. high-velocity aircraft rockets; additional armament loads are classified by the U.S. Air Force.

Editor
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Technical Advisers
Hugh L. Dryden
Robert R. Dexter
S. Paul Johnston

Business Manager
Joseph P. Ryan

Western Office
7660 Beverly Blvd., Los Angeles 36, Calif.

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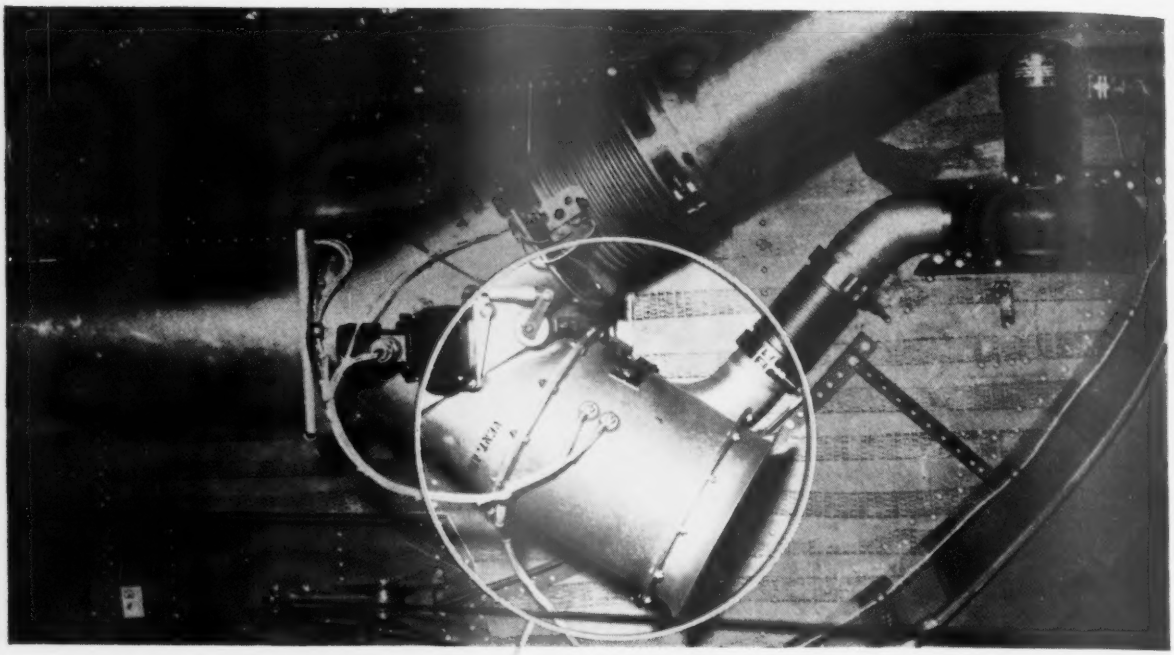

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Third Joint R.Ae.S.-I.A.S. International Conference Set for September

Twenty Papers To Be Presented During Technical Sessions at Brighton, England, September 3–7; Visits to Industrial and Governmental Installations and S.B.A.C. Flying Display Scheduled for Following Week

PLANS FOR THE THIRD GET-TOGETHER of the Royal Aeronautical Society and the Institute were rapidly being finalized as this issue went to press. Twenty papers, ten British and ten American, have been selected for presentation during the 4 days of technical sessions. Visits to aircraft and engine plants, government installations, etc., are planned for the second week's program. One day is being set aside for attending the S.B.A.C. show at Farnsborough.

▸ **Brighton Selected**—The technical sessions will be held in Brighton, where hotel accommodations and meeting facilities make it possible to carry out the week's program under one roof.

American delegates will be transferred to hotels in London the second week, from whence the various field trips, social events, and plant visits will originate.

▸ **Technical Sessions**—Registration will begin on Monday, September 3, at Brighton, and the following 4 days will be devoted to the presentation and discussion of papers. Preprints of all papers will be distributed to registered delegates at the opening of the conference. Complete transactions, including discussions, will become generally available some time after the meeting.

The technical sessions will not be restricted. Subjects to be discussed, together with the speakers selected to present papers, are as follows:

British Papers

Advances in Aircraft Design—G. T. R. Hill, University College, University of London

Research Work on Drag Reduction—Sir Melvill Jones, University of Cambridge

Influence of Size on Performance of Jet Engines—S. J. Moyes and W. A. Pennington, National Gas Turbine Establishment

Research with Laminar Flow Gliders—L. P. Coombes, Council for Scientific and Industrial Research, Australia

A Survey of Aerodynamic Advances—A. Fage, The National Physical Laboratory

Engineering Problems of Aircraft Operation—B. S. Shenstone, British European Airways

Aircraft Structures—A. H. Hall, National Research Council, Canada

Propeller Turbine Powered Aircraft—K. G. Wilkinson, British European Airways

Plastics and Plastic Structures—J. E. Gordon, Royal Aircraft Establishment

Material Properties for High Altitude Operation—T. P. Hughes, Royal Aircraft Establishment

American Papers

Aerodynamics of Wing-Body Combinations—A. H. Flax and H. Lawrence, Cornell Aeronautical Laboratory, Inc.

Structural Problems of Future Aircraft—Nicholas J. Hoff, Polytechnic Institute of Brooklyn

Aeroelasticity and Flutter—I. E. Garrick, Langley Aeronautical Laboratory, N.A.C.A.

Transonic Aerodynamics—John Stack, Langley Aeronautical Laboratory, N.A.C.A.

Dynamic Stability and Control—W. F. Milliken, Jr., Cornell Aeronautical Laboratory, Inc.

Propellers for High-Speed Aircraft—George Brady, Curtiss-Wright Corporation

Flight Safety—J. Lederer, The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University

Jet and Rocket Propulsion—L. Dunn, California Institute of Technology

High-Speed Hydrodynamic Development—E. G. Stout, Consolidated Vultee Aircraft Corporation

Jet Efficiencies—George Schairer, Boeing Airplane Company

▸ **Transportation and Accommodations**—Air transportation for the American Delegates is being arranged by the Institute with Pan American Airways and T.W.A. Group flights from New York to England will be scheduled for September 1 and 2.

Hotel accommodations and travel in connection with field trips in England are being arranged by the R.Ae.S.

All delegates will be required to pay their own travel and living expenses. A general registration fee of $25 per person, which includes the R.Ae.S. registration and minor incidental expenses, is also required.

▸ **Restrictions and Limitations**—Attendence at the Conference will be restricted to I.A.S. and R.Ae.S. members only. Because of limited travel and hotel accommodations, it may be necessary to limit the size of the U.S. official delegation to 75–80 persons. If applications are received in excess of this number, the quota will be filled by lot.

U.S. delegates must be able to show documentary evidence of security clearance (at least through "Confidential") by Air Force, Navy, or other qualified Government agency. While the technical sessions will be unrestricted, certain other discussions

and plant visits are expected to involve classified information.

The usual passport and visas are also necessary.

▸ **Applications to Attend**—I.A.S. members wishing to attend the Conference should make their requests by letter to the Institute's Secretary, Robert R. Dexter. Application forms and full particulars will then be supplied.

In order to ensure inclusion in the group, completed application forms, including registration fee, must be in the hands of the I.A.S. Secretary by May 1, 1951.

W. A. S.

Maddida Displayed During I.A.S. Annual Meeting

Maddida, a compact electronic "thinking machine," designed, developed, and constructed by the engineers of Northrop Aircraft, Inc., was placed on exhibit by Stevens Institute of Technology during the Nineteenth Annual Meeting of the Institute of the Aeronautical Sciences. This particular machine, the first production model to come out of the Northrop laboratory, was built for the Experimental Towing Tank at Stevens. The use of Maddida at Stevens is under the sponsorship of the U.S. Navy, with the Navy's BuOrd, BuShips, BuAer, and Office of Naval Research supporting and taking active part in the work being done there.

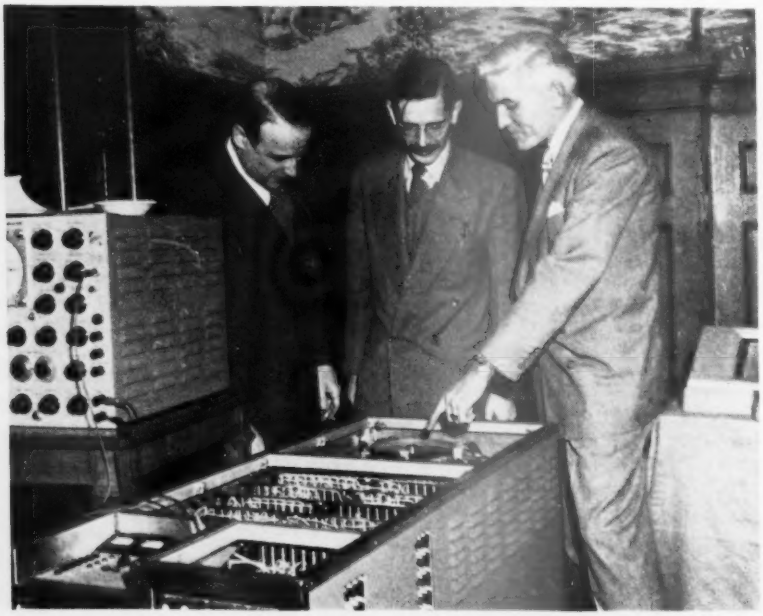
The term "Maddida" was coined from the Computer's full descriptive name, "Magnetic Drum Digital Differential Analyzer," and is pronounced to rhyme with "mad Ida."

Maddida created quite a stir during its recent demonstration at the I.A.S. Annual Meeting, for this latest of the "magic brain" electronic computers can read twelve graphs or tables simultaneously, or it can plot six graphs or type out on twelve printers at the same time that it is computing. Maddida, incidentally, does its computing with less than 100 vacuum tubes and has only one moving part, a spinning magnetic drum "memory."

Northrop's recently developed digital computer has manifold uses. It can predict the optimum design for an airplane or a ship, navigate and guide a rocket ship to the moon, or operate a factory production line. It is claimed that the computer can solve, in a matter of seconds, problems so complex that months or even years would otherwise be required to work them out on standard-desk calculating equipment.

Despite Maddida's tremendous mathematical prowess, the machine is compact and relatively inexpensive. Its inner workings feature tiny tubes packed into a cabinet smaller than the ordinary office desk. Its weight is approximately 400 lbs. Maddida's compact size and enormous mathematical capacity is said to have resulted from the application of new design techniques in computers developed by Northrop Aircraft, Inc.

MADDIDA ON DISPLAY: *Thomas Quayle (right), Director, Associated Products Division, Northrop Aircraft, Inc., points out some of the intricacies of Maddida to Dr. K. S. M. Davidson, Director (left), and Robert R. Williamson, Research Engineer, Experimental Towing Tank, Stevens Institute of Technology.*



I.A.S. Members Named to Chairmenships of N.A.C.A. Technical Committees

In an announcement issued by the N.A.C.A. Chairman, Dr. J. C. Hunsaker, I.A.S. Founder Member and Honorary Fellow, it was stated that more than 400 men have been named members of the 27 technical committees and subcommittees for 1951. Most of these appointees are civilians who were selected because of technical ability, experience, and recognized leadership in their special field of competence.

I.A.S. members who have been named Chairmen of the technical committees for 1951 include: *Aerodynamics*, Dr. Theodore P. Wright, I.A.S. Founder Member, Past-President, and Honorary Fellow, Acting President, Cornell University; *Power Plants for Aircraft*, Ronald M. Hazen, I.A.S. Founder Member and Fellow, Director of Engineering, Allison Division, General Motors Corporation; *Aircraft Construction*, Dr. Arthur E. Raymond, I.A.S. Founder Member, Past-President, and Honorary Fellow, Vice-President—Engineering, Douglas Aircraft Company, Inc.; and *Operating Problems*, William Littlewood (F.), Vice-President, Engineering, American Airlines, Inc.

Thirteen Institute members will serve during 1951 as technical subcommittee chairmen. These committees and their chairmen are: *Fluid Mechanics*, Dr. Clark B. Millikan, I.A.S. Founder Member, Past-President, and Honorary Fellow, Director, Daniel Guggenheim Aeronautical Laboratory, California Institute of Technology; *High-Speed Aerodynamics*, John G. Lee, I.A.S. Founder Member and Fellow, Assistant Director of Research, United Aircraft Corporation; *Stability and Control*, Capt. Walter S. Diehl, I.A.S. Founder Member and Honorary Fellow, Bureau of Aeronautics, U.S. Navy; *Internal Flow*, Philip A. Colman (A.F.), Chief Aerodynamics Engineer, Lockheed Aircraft Corporation; *Propellers for Aircraft*, Thomas B. Rhines (M.), Chief Development Engineer, Hamilton Standard Division, United Aircraft Corporation; *Seaplanes*, Grover Loening, I.A.S. Founder Member, Benefactor, and Fellow, Aircraft Consultant, Washington, D.C.; *Helicopters*, Richard H. Prewitt (A.F.), Prewitt Aircraft Company; *Engine Performance and Operation*, Arnold H. Redding (M.), Flow Research Section, Aviation Gas Turbine Division, Westinghouse Electric Corporation; *Rocket Engines*, Dr. Maurice J. Zucrow (A.F.), Professor of Gas Turbines and Jet Propulsion, School of Aeronautics, Purdue University; *Aircraft Structures*, Dr. Charles R. Strang, I.A.S. Founder Member and

Associate Fellow, Douglas Aircraft Company, Inc.; *Vibration and Flutter*, Raymond L. Bisplinghoff (M.), Associate Professor, Aeronautical Engineering, Massachusetts Institute of Technology; *Meteorological Problems*, Dr. F. W. Reichelderfer, I.A.S. Founder Member, Fellow, and Honorary Member, Chief, U.S. Weather Bureau; and *Aircraft Fire Prevention*, Raymond D. Kelly (M.), Superintendent of Technical Development, United Air Lines, Inc.

D. C. Sayre to Head Forrestal Research Center

Professor Daniel C. Sayre, A.F.I.A.S., School of Engineering, Princeton University, has been appointed the Director of the recently established James Forrestal Research Center at Princeton and of a five-man committee to administer its affairs. Professor Sayre, in addition to his directorial duties, will serve as Executive Secretary.

The Forrestal Research Center has been established as a memorial to the first Secretary of Defense, James Forrestal, who was also a Princeton alumnus and Charter Trustee. Its facilities will be devoted primarily to advanced research and training in the fields of aeronautical engineering, chemical kinetics, jet propulsion, and related sciences. The first units are scheduled to move into the new Center from their present locations this month.

Professor Sayre has been Chairman of the Department of Aeronautical Engineering since its organization in 1942. Prior to that time, he had served on the faculty of the Department of Aeronautical Engineering, Massachusetts Institute of Technology. From 1933 to 1939, he was Associate Editor of *Aviation Magazine* and Aviation Editor of *Newsweek*. In 1939, he became Director of Statistics and Information, Civil Aeronautics Authority, and after the Authority's reorganization, he was Chief, Safety Rules Division, C.A.B., until he joined the Princeton faculty.

Gifts to the Institute Collections

Captain Walter S. Diehl added a number of aeronautical periodicals to his previous gifts. Major General Follett Bradley, of the Sperry Gyroscope Company, sent two volumes on *The Question of Autonomy for the United States Air Arm, 1907–1945*, by R. Earl McClendon. Colonel E. E. Aldrin presented a framed map of the two world flights by Wiley Post, the first with Harold Gatty, signed by both Post and Gatty, and several framed insignia of World War I German and American squadrons. W. A. M. Burden added

Prof. Daniel C. Sayre.

periodicals to his previous generous gifts.

Dr. Eugene F. DuBois added 49 aeromedical reports to his previous gifts. Colonel Stedman Shumway Hanks presented three specially bound volumes of source material on flight strips. John P. V. Heinmuller added four albums of air-mail flight covers and two prints to his previous generous gifts, including transoceanic record flights, and Canadian and Zeppelin covers and material. K. H. Weil added technical periodicals and books to his previous gifts. The International Telephone and Telegraph Corporation presented 41 issues of *Electrical Communication*, through the courtesy of F. J. Mann.

Among the organizations adding to technical reports previously sent were the Bell Aircraft Corporation; British Joint Services Mission; Polytechnic Institute of Brooklyn; California Institute of Technology; Champion Spark Plug Company; Cornell Aeronautical Laboratory, Inc., through the courtesy of Miss Elma T. Evans; Curtiss-Wright Corporation; Defense Research Laboratory; University of Texas; Douglas Aircraft Company, Inc.; Dr. Albert Gail; Grumman Aircraft Engineering Corporation; International Air Transport Association; New Mexico College of Agricultural and Mechanical Arts; North American Aviation, Inc.; Dr. August Raspet; and the University of Illinois.

Government organizations contributing reports included the Air University Library; Ballistic Research Laboratory, Aberdeen Proving Ground; Bureau of Aeronautics; Central Air Documents Office; Civil Aeronautics Administration; Civil Aeronautics Board; National Advisory Committee for Aeronautics; Naval Ordnance Test Station, Inyokern; Naval Research Laboratory; Office of Naval Research; and the David Taylor Model Basin. The Indonesian Organization for Scientific Research and the Royal Canadian Air Force also sent reports.

Aeronautical publications were received also from the Aircraft Industries Association; Selig Altschul; Blackburn and General Aircraft, Ltd.; Boeing Airplane Company; The Dow Chemical Company; Fairchild Engine and Airplane Corporation; Found Bros. Aviation Limited; Kollsman Instrument Corporation; Lockheed Aircraft Corporation; Louisiana State University; The Glenn L. Martin Company; McDonnell Aircraft Company; Alan Munz & Company; and congressional committees on appropriations, armed services, and interstate and foreign commerce.

Necrology

Thomas Henri Huff

A Tribute by Jerome C. Hunsaker, D.Sc.

The death of Thomas Henri Huff, I.A.S. Associate Fellow and Founder Member, on December 23, 1950, marks a break with the past for many of our older members who will recall the active part played by Tom Huff in the pioneering decade, 1916–1926. I recall his graduation from M.I.T. in 1915 and his subsequent service as my assistant. A 4-ft. wind tunnel had been constructed in accordance with the plans of Leonard Bairstow's 4-ft. tunnel at the National Physical Laboratory in England. Our first research project was to establish the dynamical stability parameters for the somewhat unsatisfactory Curtiss JN2. The experimental wind-tunnel work was undertaken by Donald W. Douglas, T. H. Huff, H. K. Chow, and V. E. Clark.

Huff was not entirely satisfied that wind-tunnel data, obtained from a rigid model and inserted into very approximate differential equations of motion, could be safely used to predict the dynamical stability of the real airplane. He undertook to make a flying model of the stable Burgess-Dunne tailless machine propelled by a motorcycle engine. This enterprise eventually resulted in a flying machine that fully represented the unreliability of its prototype. It would fly, as I recall it, only

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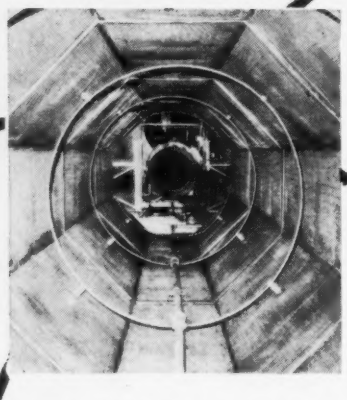

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on alternate Saturdays. The general conclusion was reached that only qualitative information could be obtained in this way and that a great deal of further development of instrumentation and control was needed. It actually took some 25 years of such development before useful target "drones" were available. Now, 35 years later, we are flying guided missiles to get telemetered performance data. Huff's pioneering idea was far ahead of the state of the art.

Huff left M.I.T. in 1916 to join Grover Loening at the Sturtevant Aeroplane Company to work a pioneer attempt at an "all-metal" airplane. There was no Duralumin or stainless steel available then, and the airplane proved to be heavier and more expensive than contemporary wood and wire construction. Again, the idea was ahead of the state of the art, but not very far ahead. Within 5 years, Junkers in Germany and others abroad, as well as Stout in this country, had produced practical metal airplanes.

The entry of the United States into World War I in 1917 put a stop to experimenting at Sturtevant, and Huff joined Charles Day at Standard Aero Corporation as his Chief Engineer. A line of conventional biplane trainers was produced in quantity and components for a bomber of European design to be assembled abroad. Liquidation of Standard Aero after the Armistice in 1919 forced Huff to shift to the Naval Aircraft Factory at Philadelphia, where he got further design experience.

This job was not congenial, since Huff really wanted a free hand to evolve his own designs. He made his opportunity by promotion of the Huff-Daland Company in 1920, with himself as President. For the next 7 years, this firm (first at Ogdensburg, N.Y., and then at Bristol, Pa., under the name of Huff-Daland Airplanes, Inc.) pioneered in three important fields—advanced trainers, crop dusting, and light bombers. The Petrel trainers were also developed as commercial three and four seaters and as crop dusters. In 1922, 2,000 acres were effectively treated by Huff-Daland Dusters, Inc., and in 1926 about 100,000 acres were treated. Fourteen airplanes were employed. However, such vigorous pioneering proved too costly to survive commercially.

The bomber development, based on biplane models LB-5 and LB-6, led to the supply to the Air Corps of about 150 aircraft up to 1930. The company reorganized in 1927 as Keystone Aircraft Corporation, without Huff, and continued the manufacture of the standard Air Corps light bomber.

This date marks Huff's separation from general airplane design. He opened offices as a consulting engineer and, for the rest of his life, was occupied with the particular problems of

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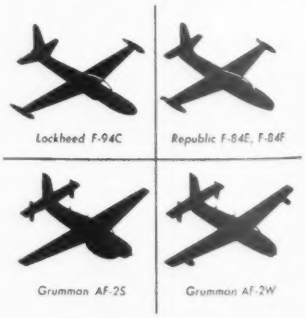
1. Accurate positioning of the driven device
2. Elimination of damage from overtravel or overload

See condensed literature in 1951 I.A.S. Aeronautical Engineering Catalog or write for Bulletin 118.

ROTORette
is currently used on these planes



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various clients. No doubt, these clients received valuable and honest advice, but one wonders whether Tom Huff should not have somehow contrived to stay with design, which was his first love. He had the imagination, the courage, and the technical ability to carry through pioneer design and construction projects in the face of the unknown and the unknowable.

It is wholly unsatisfactory to speculate on the contributions to the art that Tom Huff might have made had his work been kept focused. However, the depression of the 1930's was hard on many pioneers of the 1920's. They dropped out of step with later aeronautical progress from lack of opportunity to participate.

However, we should remember Tom Huff as a pioneer of the 1920's. Those who now practice this art should recall Tom Huff among those whose work is embedded in the foundations of their profession.

Paul E. Tuntland

Paul Elliott Tuntland, A.M.I.A.S., was fatally injured in an airplane accident on September 9, 1950. He was 28 years old.

A native of Buckingham, Ill., Mr. Tuntland attended the Covina (Calif.) High School and Pasadena (Calif.) Junior College. During his first 2 years out of school—from 1940 to 1942—he was associated with the aircraft manufacturing phase of the aeronautical industry. In 1942, however, he started the research and test-piloting part of his career. Holding C.A.A. Commercial Certificate No. 34618 with airplane, glider, multiengined, land-sea, and flight-instructor ratings, he was employed during these last 8 years as Research and Test Pilot. Some of the groups with which he was allied during this period included the Army Air Force; Soaring Society of America; Aerophysics Institute, Inc.; and, most recently, Western Air Lines, Inc. During 1946, he served as Senior Research Pilot for the Sailplane Section, Thunderstorm Project, and for a time also served as airflow-study pilot for the Office of Naval Research, U.S. Navy.

Mr. Tuntland was the coauthor of *Aviation Ground Trainer Manual*, used in the Los Angeles public schools.

Walter R. Wall, Jr.

Walter R. Wall, Jr., T.M.I.A.S., was kill-d last December 9 as a result of a helicopter crash during a regular flight test of the helicopter at the Naval Air Station, Patuxent River, Md.

Born in Brooklyn, N.Y., on August 7, 1926, he attended the Red Bank (N.J.) Catholic High School and The Catholic University of America. He was graduated from the latter in June, 1949, with a B.A.E. degree. He had been taking work leading to a Master's degree in Mechanical Engineering with the Aeronautical Engineering option at the University of Maryland.

At the time of his death, Walter Wall was employed as a Project Engineer in the flight testing of helicopters, Rotary Wing Section, Flight Test Division, Naval Air Test Center, Patuxent River. He had been with this Section since July, 1949.

News of Members

▸ **William A. M. Burden,** Founder Member, Benefactor, and Past-President of the I.A.S., has been appointed Deputy to Under Secretary of the Air Force John A. McCone in Mr. McCone's capacity as the Air Force civilian member of the Department of Defense Research and Development Board. Mr. Burden, a partner in William A. M. Burden & Company, is Special Assistant to the Secretary of the Air Force.

▸ **Dr. Charles S. Draper** (F.), Professor of Aeronautical Engineering and Director of Instrumentation Laboratory, Massachusetts Institute of Technology, was given the Exceptional Service Award, the highest civilian decoration in the gift of the Air Force. Dr. Draper, in conjunction with the Sperry Gyroscope Company, developed a computing gunsight for fighter planes.

▸ **A. Felix duPont, Jr.** (A.M.), Director, Piasecki Helicopter Corporation, has been appointed to the Board of Managers, The Franklin Institute of the State of Pennsylvania, to fill the vacancy created by the death of his uncle, E. Paul duPont.

▸ **Sir Frederick Handley Page,** C.B.E. (H.F.), Chairman and Managing Director, Handley Page, Ltd., England, was appointed Chairman, City and Guilds of London Institute, England.

New **LORD**
***TEMPROOF Mountings**

- **Exceed AN-E-19 Drop Test Requirements**
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*Temperature-proof

Here is reliable vibration protection for base-mounted airborne electronic equipment . . . and for other apparatus which must function properly above and below usual temperatures. And TEMPROOF Mountings are priced to meet the needs of manufacturers in competitive markets.

TEMPROOF Mountings provide superior protection by maintaining their high vibration-isolating efficiency from −80°F to +250°F. Selective-action friction dampers prevent excessive movement at resonant frequencies. Equipment does not sag or droop . . . mounting drift is negligible. The unusually wide load range of TEMPROOF Mountings makes it possible to standardize on one mounting for several types of equipment, and to effect additional economies in purchasing, storage and assembly.

For complete information on TEMPROOF Mountings, or for specific recommendations concerning their use, write to Product and Sales Engineering Department. A quantity of Vibration Isolation and Natural Frequency Charts in full color is available. Copy of each will be sent free upon request.

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Members on the Move

This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

William J. Arnold (T.M.), Layout and Design, Wean Equipment Corporation. Formerly, Layout and Design Draftsman, Appliance Manufacturing Company.

L. A. Carter (A.F.), Division General Manager, Douglas Aircraft Company, Inc., Santa Monica. Formerly, Plant Manager, Douglas Santa Monica Plant.

Laurance H. Cooper (A.M.), Head, Aircraft Department, Rheem Manufacturing Company. Formerly, Vice-President and General Manager, Pacific Airmotive Corporation.

Vernon G. Crudge (M.), Consultant, Munitalp Foundation. Formerly, General Manager, Western Division, British Overseas Airways Corporation.

Aaron Epstein (M.), now Stress Analyst "A," North American Aviation, Inc.

H. S. Fletcher (T.M.), now Junior Aerodynamics Engineer, The Glenn L. Martin Company.

Alfred T. Gregory (M.), Head, Engineering Division, Fairchild Engine Division, Fairchild Engine and Airplane Corporation. Formerly, Chief Engineer, Fairchild Engine Division.

Charles L. Hall (A.F.), Expediter—Air Materiel Command, Bell Aircraft Corporation. Formerly, Chief Project Engineer, Fighter Branch, Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base, Ohio.

Lewis H. Height (M.), Project Engineer, Lockheed Aircraft Corporation. Formerly, P2V Assistant Project Engineer, Lockheed.

F. W. Herman (M.), Division General Manager, Douglas Aircraft Company, Inc., Long Beach. Formerly, Plant Manager, Douglas Long Beach Plant.

Carl G. Holschuh (*M.*), *Vice-President and Assistant General Manager for Manufacture, Sperry Gyroscope Company, Division of The Sperry Corporation. Formerly, Vice-President for Manufacturing, Sperry Gyroscope.*

SMITHSONIAN ADDING DURAND VARIABLE-PITCH PROPELLER TO MUSEUM COLLECTION

The first variable-pitch propeller, developed in 1918 by Dr. William Frederick Durand, 91-year-old dean of America's aeronautical engineers, is being added to the collection of significant aeronautical inventions in the Smithsonian Institution's National Air Museum. This model, the "granddaddy" of the modern aircraft propellers, revolutionized the construction of propellers when it was built and tested by Dr. Durand and the late Prof. Everett Parker Lesley (1874-1945) in a Stanford University wind tunnel 33 years ago. Prior to this time, all aircraft propellers were of the fixed-pitch type. Dr. Durand is an I.A.S. Founder Member and Honorary Fellow; Professor Lesley was also one of the Founder Members of the Institute.

John W. Hobbs (T.M.), now Flight Test Engineer, Consolidated Vultee Aircraft Corporation, San Diego.

George Jacobs (T.M.), Junior Structural Test Engineer, The Glenn L. Martin Company. Formerly, Engineering Draftsman, Martin.

John T. Kutney (T.M.), now Design Engineer, Bell Aircraft Corporation.

Archie Crusoe Landry (T.M.), now Engineer Designer, Douglas Aircraft Company, Inc.

Raymond J. LaRochelle (T.M.), now Design Draftsman, Lockheed Aircraft Corporation.

Joaquin Larzabal (T.M.), Chief of Technical Control, Technical Department, Base Aerea El Plumerillo, Mendoza, Argentina, and Director, Estudio Industrial y Comercial, Mendoza. Formerly, Flight Test Engineer, Instituto Aerotecnico, Cordoba, Argentina.

Everard M. Lester (A.F.), Assistant General Manager, Fairchild Engine Division, Fairchild Engine and Airplane Corporation. Formerly, Director of Engineering, Fairchild Engine Division.

Lieutenant Colonel William C. Lazarus (M.), Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base, Ohio. On military leave of absence as Quality Control Supervisor, Chase Aircraft Company, Inc.

Lloyd G. Ludwig (M.), Research Engineer for the development of rocket motors, etc., Aerophysics Laboratory, North American Aviation, Inc. Formerly, Associate Research Mechanical Engineer, Cornell Aeronautical Laboratory, Inc.

K. R. Luther (T.M.), Instrumentation Design Engineer, Century Engineers, Inc. Formerly, Designer, Commercial Casting Company.

E. J. Lynch (T.M.), Group Leader, Structural Test Laboratory, A. V. Roe Canada Limited. Formerly, Structural Test Engineer, Avro Canada.

Lieutenant Harvey W. MacFarland (A.M.), Staff Intelligence Officer, 106th Bombardment Group, New York Air National Guard, Floyd Bennett Field, N.Y. On military leave of absence as Assistant Purchasing Agent, Permatex Company, Inc.

Donald Dean Martin (T.M.), Junior Engineer, Fort Worth Division, Consolidated Vultee Aircraft Corporation. Formerly, Service Liaison Man "A," Convair, Fort Worth.

Leon L. Matalon (T.M.), now Structural Engineer, Chase Aircraft Company, Inc.

Robert W. Middlewood (M.), Chief Engineer, Lockheed Aircraft Corporation, Marietta, Ga. Formerly, P2V Project Engineer, Lockheed.

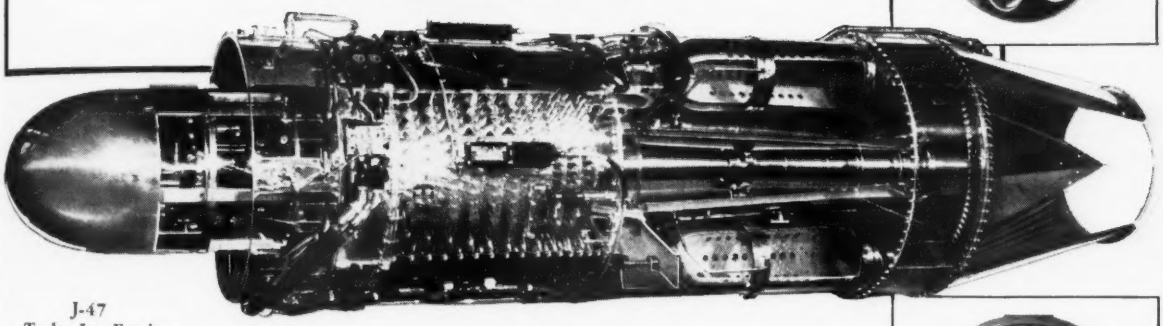
Edward S. Miller (T.M.), 2nd Lt., U.S. Air Force. Formerly, with Republic Aviation Corporation.

(*Continued on page 100*)

APPOINTED BY BORG-WARNER

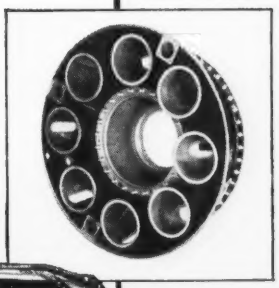
Dr. Maurice Nelles (M.) has been appointed by the Borg-Warner Corporation as Director of the Engineering Development Section. Dr. Nelles was previously Director, Engineering Experimental Station, and Professor, Engineering Research, at The Pennsylvania State College. He has also been Engineering and Research Manager, Hancock Foundation, University of Southern California, and Senior Research Engineer, Lockheed Aircraft Corporation. During the last war, he was Deputy Director and Chief Engineer, War Production Board.

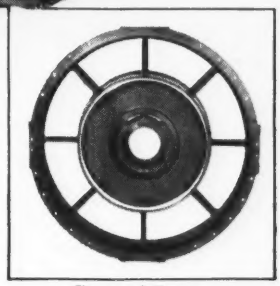
JET ENGINES and COMPONENTS by FAIRCHILD



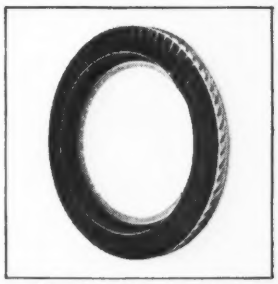
J-47
Turbo Jet Engine

Rear Frame

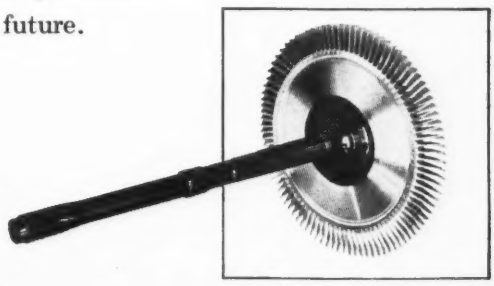




Forward Frame



Nozzle Diaphragm Ring



Complete Turbine
Wheel Assembly

The Fairchild Engine Division is designing, and producing specialized turbine engines—some of them for unconventional applications—and is mass producing such vital components of General Electric's J-47 engine as the turbine wheel and shaft, nozzle diaphragm, and the forward and rear compressor frames—main supporting structures of the engine.

Geared to the exacting requirements of aircraft engine production, Fairchild is able to meet the expanding demands of the military establishments and take its place in the rearmament program; producing in volume urgently needed components and pressing forward the development of turbine and reciprocating engines for specialized application in the military equipment of the future.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Engine Division
FARMINGDALE, N. Y.

Other Divisions: Fairchild Aircraft Division, Hagerstown, Md. • Fairchild, Guided Missiles Division, Al-Fin Division, and Stratos Division, Farmingdale N.Y.

Service for Contractors

Symposium on Standardization in Technical Information Services for Government Contractors

THE MAXIMUM USE of reported research and development results by Government contracting companies and laboratories was the target at the symposium on technical information services held in New York in January. Representatives of four Government agencies, handling about 80 per cent of the technical reports arising from current national defense research, told the industry of recent developments on which they are working together. Simplification for the user of research reports through standardization of processes, of equipment, and of the reports themselves and integration on the organization level were the main lines of discussion.

Expected establishment of an Armed Services Technical Information Agency (ASTIA), combining the present Central Air Documents Office (CADO) and the Navy Research Section of the Library of Congress (N.R.S.), was announced. The Chairman, Dr. Eugene W. Scott, Executive Secretary of the Interdepartmental Committee on Scientific Research and Development, said that under the directive establishing ASTIA, awaiting Defense Secretary Marshall's signature, "we will have authority to operate a single centralized documentation service, under one security office and one security clearance." This agency will collect reports; compile abstract bulletins; make catalog cards; distribute documents, abstract bulletins, and catalog cards; and compile bibliographies for contractors requesting them.

The speakers were E. Eugene Miller, Chief, Division of Research Information, N.A.C.A.; Dr. Dwight E. Gray, Chief of N.R.S.; Col. Albert A. Arnhym, Director of CADO; and Dr. Mortimer Taube, Deputy Director, Technical Information Service, Atomic Energy Commission. They described briefly the technical information work of their agencies but concentrated upon the work of the informal group for standardization of technical information services (g.s.i.s.). This group was described by Dr. Scott as "a sort of stepchild of ASTIA, which we hope will be adopted when ASTIA comes of age."

Agreement has been reached on several points by g.s.i.s. in its monthly meetings, held since June, 1950. A common catalog card (illustrated below) is now in use by all four agencies. Interfilability of cards from two or more of the agencies has been made possible by working out a common list of subject headings for indexing and a common list of originating agencies of reports. Both of these lists have progressed to a point where they are usable by all the agencies. The list of subject headings will eventually be published

The "marginal" catalog card is familiar in principle to users of the *Technical Information Pilot* and cards of the Atomic Energy Commission. Aside from its use in card catalogs, it is adaptable for mounting into pages of two or three columns to form abstract bulletins and cumulative indexes. Only the parts of the card needed are used. The other parts are masked by the overlapping of cards or by masking tape. Work has begun on a machine method for mounting cards into pages. This was described as a fairly simple problem technically. Only one typing and one proofreading are necessary for any use made of the card, since photography is the method of "printing" in the desired size for all processes.

The agencies have agreed to discontinue the processing of one another's reports. They will use one another's abstract bulletins and cards instead. The master list of subject headings now in progress will make possible a common index to the abstract bulletins or the regular lists of all the agencies.

The cataloging of reports and preparation of abstracts, abstract bulletins, cumulative indexes, and bibliographies will be accomplished by the Navy Research Section under ASTIA.

The extensive published sources in the Library of Congress are used in the preparation of more extensive bibliographies going beyond the document holdings of N.R.S. The *Technical Information Pilot* will be continued in expanded form. *TIP* cards and *ATI* cards will be merged into a single card service, designated MTI (Military Technical Index) cards.

The distribution of technical reports, abstract bulletins, and catalog cards will be the responsibility of CADO under ASTIA. CADO will also have responsibility for collecting reports.

Distribution processes were discussed in detail by Colonel Arnhym on the basis of security requirements, contractors' rights, and contract requirements. The IBM system of control and the present combination of IBM and Addressograph equipment are expected to handle the load under ASTIA.

More machine methods were emphasized as a definite need for the future in the control of documents for information requirements. The Atomic Energy Commission is transmitting printed pages by facsimile methods between two laboratories at the rate of 120 sq.in. per min. The application of mathematical analogs to the indexing of documents was a project mentioned briefly. Dr. Taube said that the electronic selector for searching and similar devices will probably be fully effective only when improved methods of indexing have been achieved.

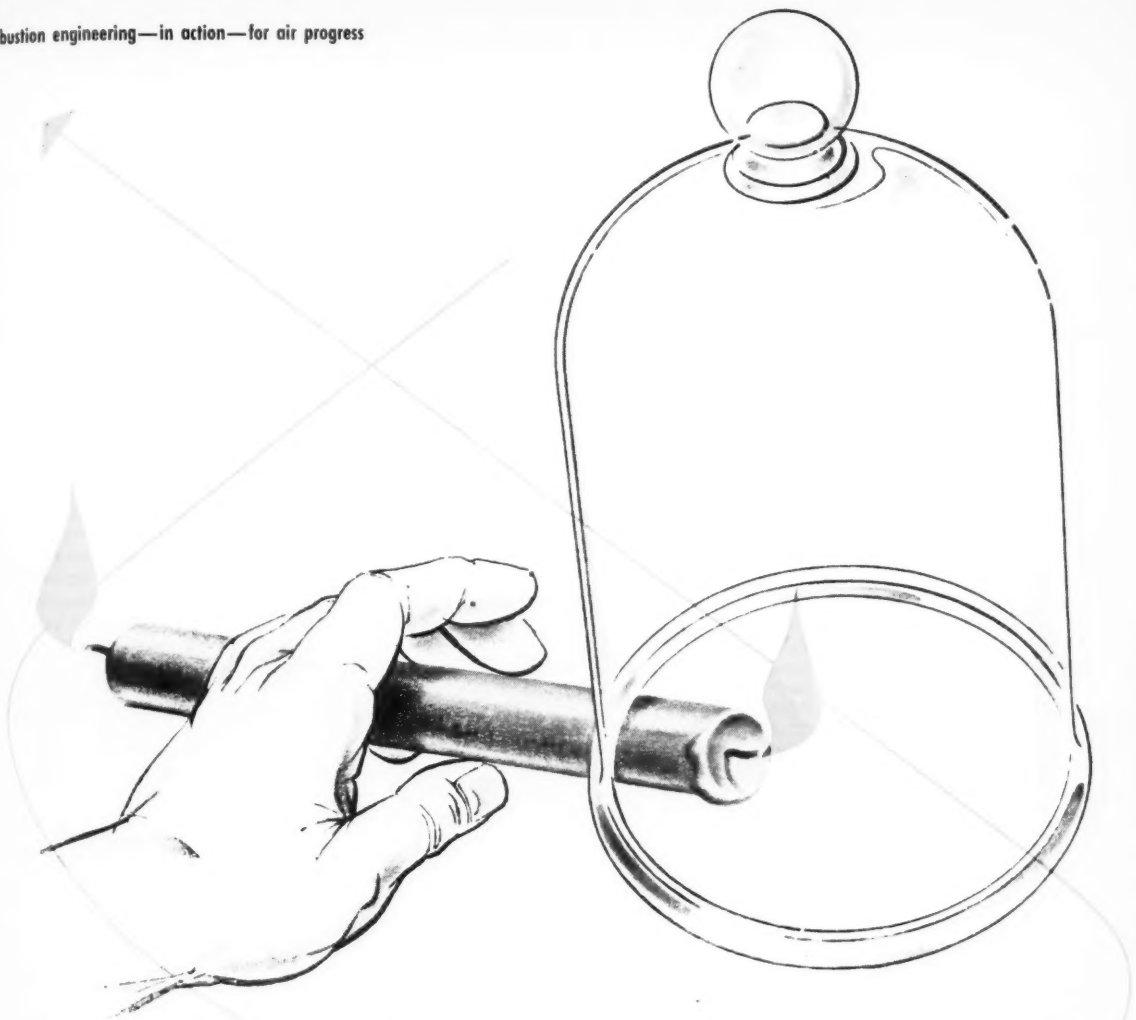
Microreproduction must also be a package deal, including a reading machine of reasonable size and cost. A special new contract was announced through which the Navy Research Section will include a microcard copy with the cards for all unclassified and restricted documents for a trial period of about 6 months. A reader can be rented for $5.00 per month.

The Symposium was co-sponsored by the I.A.S. Libraries and the Science-Technology Division of the Special Libraries Association.

MAURICE H. SMITH
Librarian, I.A.S.

AECU-754 Brookhaven National Lab. SOME OBSERVATIONS OF THE EPITAXY OF SODIUM CHLORIDE ON SILVER, by G. W. Johnson. Dec. 2, 1949. 12p. incl. illus. 13 refs. (AECU-754) UNCLASSIFIED The orienting effects of Ag on NaCl crystallized from solution were investigated. Strong epitaxy was observed in oriented films of Ag with (100) and (111) planes parallel to the surface and polycrystalline high purity Ag. The orientation of a small nucleus or embryo in determining the orientation of the entire crystal is supported by the growth of crystallites across grain boundaries without affecting the orientation of the growth. The orienting characteristics of Ag on NaCl were recommended as an indication of relative orientations in polycrystalline material and of testing degree of orientation in oriented thin films.	UNCLASSIFIED 1. Sodium chlorides--Crystallization 2. Silver--Properties I. Johnson, G. W. 0000-50 Cat. 99 N-X-5 U. S. AEC UNCLASSIFIED

combustion engineering—in action—for air progress



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Corporate Member News

• **Aeroproducts Division, General Motors Corporation** . . . Facilities at the Dayton (Ohio) Municipal Airport are being doubled because of increased production orders for propellers for the Fairchild C-119, the Douglas A2D, and the Convair R3Y. A new building will be constructed adjoining and to the rear of the present building. When completed, there will be 500,000 sq.ft. of manufacturing, laboratory, and office space.

• **Allis-Chalmers Manufacturing Company** . . . The physical assets of Canadian Allis-Chalmers, Limited, have been purchased by a wholly owned Allis-Chalmers subsidiary. The new subsidiary is known as Canadian Allis-Chalmers (1951) Limited; it will continue the production of heavy machinery for the Canadian market. Included in the purchase was 17 acres of land on which are five buildings. These comprise welding, machine, and pattern shops, as well as a pattern storage building and an office building.

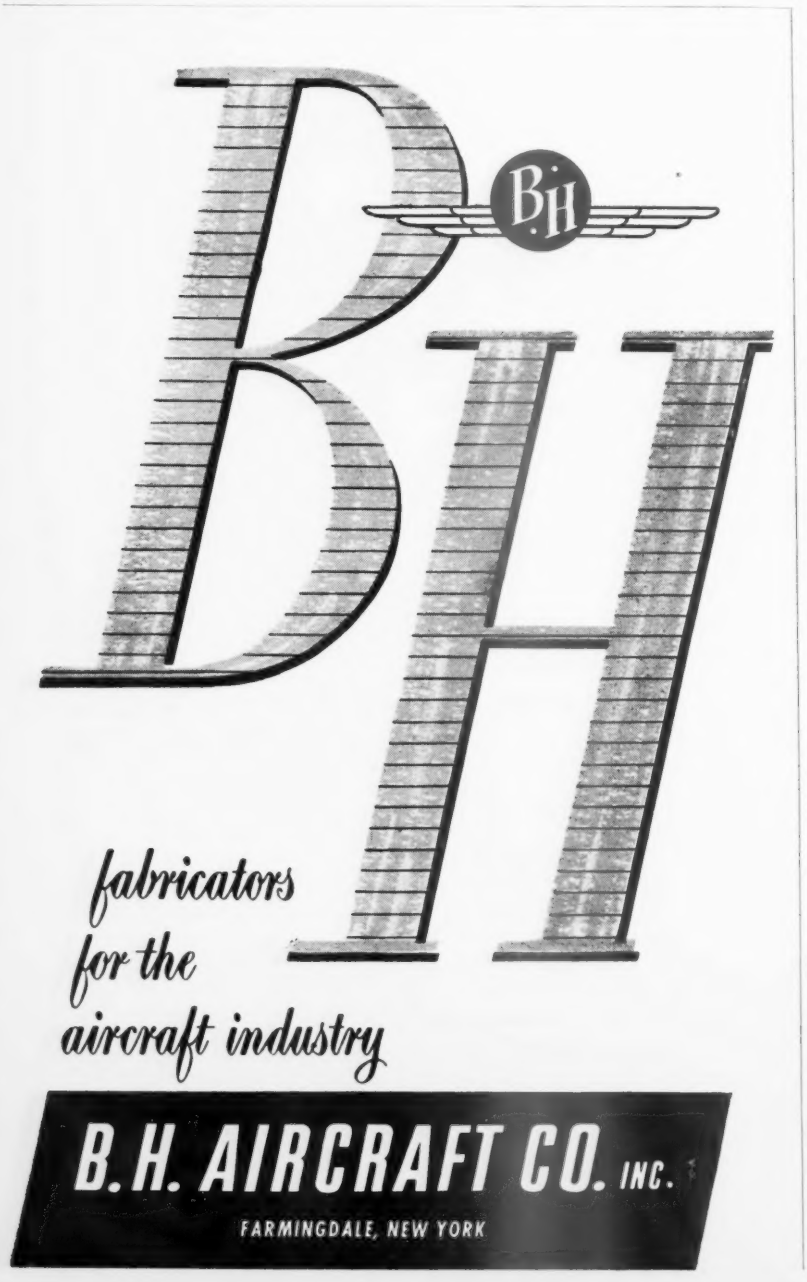
• **Aluminum Company of America** . . . According to an announcement last January, the construction of a new alumina plant near Bauxite, Ark., was scheduled to have been begun immediately. To be operated by Aluminum Ore Company, an Alcoa subsidiary, the new plant will be situated on a 200-acre site adjoining the bauxite mining operations of Alcoa Mining Company, another subsidiary concern. The entire construction project will be carried out by Alcoa, serving as its own general contractor.

• **Beech Aircraft Corporation** . . . The new C35 Bonanza, designed especially for business and executive use, was unveiled last January. In general, the performance characteristics of the new C35 have been increased over those of the earlier model, the B35 Bonanza. Take-off rating is 205 hp. at 2,600 r.p.m.; normal rating is 185 hp. at 2,300 r.p.m. The C35 has a cruising speed of 175 m.p.h. at 8,000 ft. and at top speed of 190 m.p.h. Its service ceiling is given as 18,000 ft., and its absolute ceiling is listed as 19,800 ft. Included as standard equipment is the new "Beechcraft Hi-Strength Safety Harness," designed by Beechcraft engineers to exceed present C.A.A. requirements for aircraft safety belts. This safety belt may be worn by each passenger with shoulder straps in place of or as a safety belt only.

• **Bendix Aviation Corporation** . . . The Ford Motor Company's plant at Hamilton, Ohio, has been purchased for the production of aircraft parts and accessories. This plant, to be operated as a new Bendix division, consists of three buildings with a total of 156,218 sq.ft. of manufacturing floor space.

• **Bendix Radio Division, Bendix Aviation Corporation** . . . Forty acres of land, two airplane hangars, and several smaller buildings at Baltimore's Pimlico Airport have been acquired on a 3-year lease to meet added space requirements of an accelerated production program. The buildings are to be remodeled for use as laboratories and classrooms, where Air Force ground personnel will be trained to maintain military electronic equipment.

• **Boeing Airplane Company** . . . Boeing and Bristol Aeroplane Company, England, have signed an agreement providing for technical collaboration in research and development work on certain defense projects of common interest. Under this agreement, Boeing will provide Bristol with engineering data already developed by Boeing in the field covered by the agreement. Thereafter, there will be a mutual exchange of technical information on further work of the two companies in the same field. The agreement also calls for an interchange of technical personnel, on a limited scale, on the particular projects covered. The arrangement is intended as a means of gaining time in the slow process of technical research and development. . . Under the terms of a contract announced in January, the modernization of the University of Washington's F. K. Kirsten Aeronautical Wind Tunnel will be financed by Boeing. The contract provides for an initial payment of $20,000 for tunnel improvements and advances up to an additional $20,000 for the project, if necessary. The funds, to be used for soundproofing the tunnel's interior and installing a new balance system for improved methods of model testing, will be considered as prepaid rent for the use of the tunnel by Boeing. Accordingly, Boeing will have priority on its use during the next



2 years while its own aerodynamic laboratory is undergoing modernization.

• **Brown Instruments Division, Minneapolis-Honeywell Regulator Company . . .** The acceleration of research through the use of industrial and related instruments and apparatus is the subject of an 8½-by-11, 84-page book just published by Brown. The book describes many types of equipment which, alone or in combination with other apparatus, are being used in research and analytical studies. It is entitled *Instruments Accelerated Research—Bulletin 15-14.*

• **The Cleveland Pneumatic Tool Company . . .** A $2,500,000 expansion program has been started to boost the output of landing gear and other products; $1,000,000 of the total, privately financed, covers plant expansion, rearrangement, and machine tools. The balance covers machine tools being acquired under a Government contract. The program is expected to be completed by the middle of July, 1951.

• **Consolidated Vultee Aircraft Corporation . . .** "Hidraw," a method of forming and drawing sheet-metal parts, has been developed at the Fort Worth Division and is now in full production use there. The only tooling necessary with Hidraw is a punch and a pressure pad, thus eliminating the die set and the female die member. The punch and the pressure pad are mounted on the lower surface of a hydraulic press, and a pad of extremely tough rubber on the upper surface of the press serves as the female die. With the metal to be formed placed atop the punch and pressure pad and the press raised until the metal is confined against the rubber, the pressure builds up to several thousand pounds per square inch. The rubber forces the metal down and around the pattern in exactly the form required. . . A steel indoor "drydock" for the simultaneous construction of two Navy R3Y-1 turboprop flying-boat hulls is nearing completion. The fully demountable twin-hull buck is more than 150 ft. long and 65 ft. wide. Three main working levels are provided with a fourth story for the tail-assembly area. Overhead monorails are installed along the tops of the deep hull wells, so that completed hulls can be transported by crane from the buck to beaching cradles for final assembly. . . An RB-36D reconnaissance airplane, on a nonrefueling test flight from the Fort Worth Division, flew for 51 hours, 20 min. without landing. The ship took off at 9:05 a.m., January 14, and landed at 12:25 p.m., January 16.

WILLIAM VAN DUSEN IN E.A.L. POST

Captain Edward V. Rickenbacker, President and General Manager of Eastern Air Lines, Inc., has announced the return to the commercial aviation industry of William Van Dusen, dean of aviation publicists and international authority on air transport, as an E.A.L. Vice-President. In his new post as a Special Assistant to Captain Rickenbacker, Mr. Van Dusen will coordinate the air line's Public Relations, News Bureau, and Advertising. A pioneer in the air-line field, he originally organized and for 20 years directed the public relations activities of Pan American World Airways, from which he resigned a year ago to devote himself to independent consultant work and to writing.

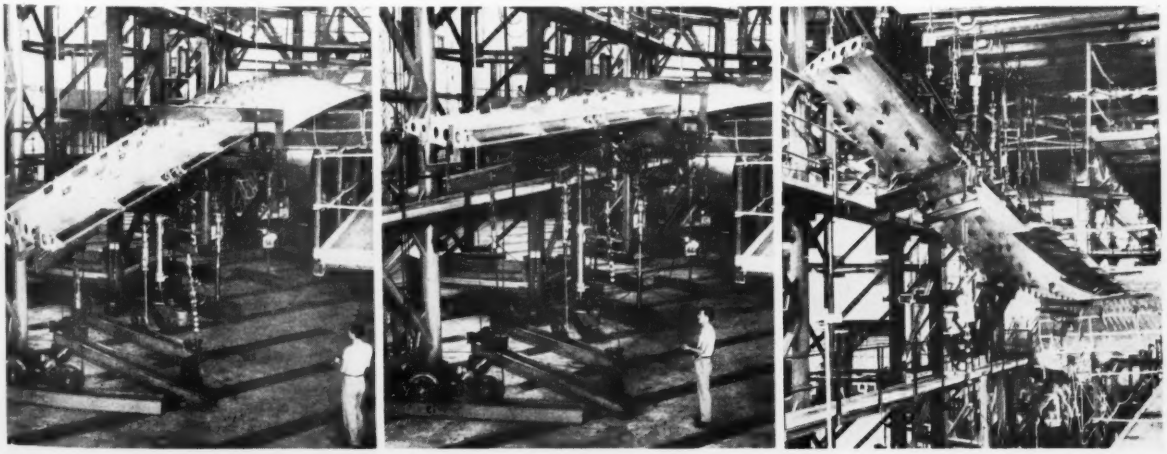
• **Curtiss-Wright Corporation . . .** For the purpose of consolidating all Curtiss-Wright electronics activities and permitting expansion in the electronics field, the Electronics Division has been created. The headquarters of this new division are located at Caldwell, N.J. . . . A new program for the training, education, and advancement of employees has been inaugurated at the North Jersey plants. The new project, known as the Curtiss-Wright Educational Institute, will ultimately include employees in all divisions of the Corporation.

• **Douglas Aircraft Company, Inc. . . .** The development of a turboprop version of the Douglas C-124A Globemaster II has been disclosed. The prototype, now under construction, will be designated the YC-124B and will be powered with four Pratt & Whitney YT34-P-1 turboprop engines each developing 5,500 hp.

• **Eclipse Machine Division, Bendix Aviation Corporation . . .** A new Automotive Electric Fuel Pump has been announced which, it is claimed, will deliver up to 30 gal. per hour with static pressures up to 7.0 lbs. per sq.in. obtainable. The 1-lb., 13-oz. pump, powered by a solenoid, is now being produced for operation on 6-, 12-, and 24-volts direct current. The 110-volt alternating-current version is under development.

B-47 COMPLETES "TORTURE TESTS"

Structure tests have proved the Boeing B-47 Stratojet capable of exceeding all of its U.S.A.F. design safety requirements, according to a Boeing Airplane Company announcement. The tests, just completed at the Wichita Division, subjected one of the 185,000-lb. jet bombers to more structural stresses and strains than it would normally encounter in years of combat flying. Loads of more than 700,000 lbs. were applied to the airplane through hydraulically actuated jacks, it was revealed. The sequence of photographs shown below shows three steps in structural testing of the thin sweptback wing of the B-47. In the left photo, a simulated load bends the tip downward more than 6 ft. In the right photo, the wing bends upward more than 11 ft. during the flight-load phase of the test. The center photo shows the normal static position of the wing. During the overload tests the up- and down-bending of the wing tip described an arc of more than 20 ft.



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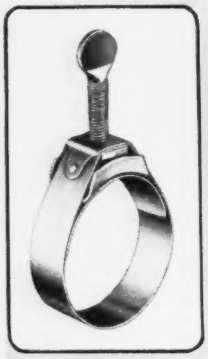
HOSE CLAMPS

For over a quarter century, Wittek has specialized in hose clamps, devoting craftsmen's skills to producing hose clamps of uniform accuracy in clamping action combined with superior physical strength, for dependable leakproof hose connections. This experience is yours when you place your aircraft hose clamp requirements with us.



WITTEK FBSS
(Radial Type)
Made of stainless steel and utilizing the Wittek Floating Bridge. Tested and proved for dependable service on all types of aircraft applications. Long accepted as the standard of the industry.

WITTEK WWD
(Tangential Type)
Made of stainless steel and available in all standard aircraft sizes. Also furnished in diameters up to 12" for duct and other special applications. Permits easy installation when hose is in place.

Meet current AN specifications and have C.A.A. approval.

Write for Details

WITTEK *Aviation* HOSE CLAMPS
MANUFACTURING CO.
4332 West 24th Place, Chicago 23, Illinois

• **Fairchild Engine and Airplane Corporation . . .** A contract of sale was signed last February 2 for the purchase of 32 acres of land on Long Island suitable for construction of 1,000,000 sq.ft. of facilities for defense production. It is anticipated that the first portion of the projected facility should be ready for occupancy within 4 months of the date of purchase.

• **Fairchild Engine Division, Fairchild Engine and Airplane Corporation . . .** The Valley Stream, L.I., plant that was occupied during World War II by Columbia Aircraft has been leased from the U.S. Government and will be used for the manufacture of jet-engine components and for the production of parts and assemblies for an auxiliary power plant used in aircraft. This newly acquired plant has approximately 150,000 sq.ft. of floor space.

• **General Electric Company . . .** The availability of a new 4-page, two-color bulletin on Tri-Clad high-speed synchronous generators has been announced. Designated as *GEA-5470*, the publication covers generators for standby, portable, and prime-source power in ratings from 1.875 to 50 kva. with frequencies of 60 and 400 cycles.

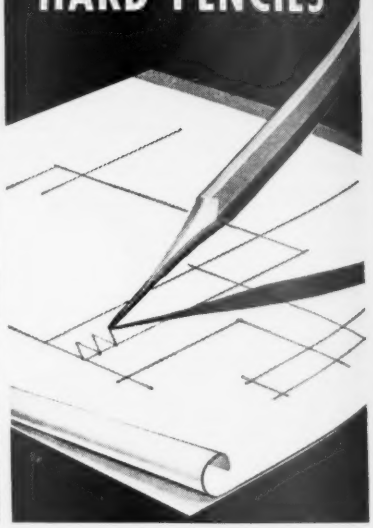
• **The Goodyear Tire & Rubber Company . . .** A new fuel tank capable of holding some 3,000 gal. is being constructed for the Convair B-36 at Goodyear. The fuel cell, which fits into the metal shell of a giant fuel tank, is made of pliocel nylon and weighs less than 0.085 lb. per sq.ft.

• **Hamilton Standard Division, United Aircraft Corporation . . .** A new machine for the mass production of turbine blades for turbojet and turboprop engines has been developed. The machine, using an endless abrasive belt to strop the blades, is suited for finishing the blade surfaces after they have been rough ground. It will also process the blade from the rough forging to finished blade if necessary and can remove up to about 0.0937 in. of stock in 15 min. or less. . . A training program for Air Force technicians in charge of propeller maintenance and instruction at the nation's Air Force bases was recently launched. Classes of twelve men are being graduated every 3 weeks after intensive indoctrination in various types of Hamilton Standard propellers installed on modern Air Force aircraft.

• **Walter Kidde & Company, Inc. . . .** The Aviation Division, now engaged in an extensive pneumatics development program, has announced that present results of these experiments indicate that compressed-air power sources used to actuate control surfaces, landing gear, wing flaps, brakes, and similar equipment may, within the next few years, replace currently used hydraulic and electrical systems.

• **Lockheed Aircraft Corporation . . .** It has been announced that a contract has been signed with Kaiser-Frazer Corporation for the fabrication and assembly of components of the Lockheed P2V. The sections to be built under the subcontract agreement will be manufactured at the Kaiser-Frazer aircraft division plant, Oakland, Calif.

Imperial
TRACING CLOTH FOR HARD PENCILS



• Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

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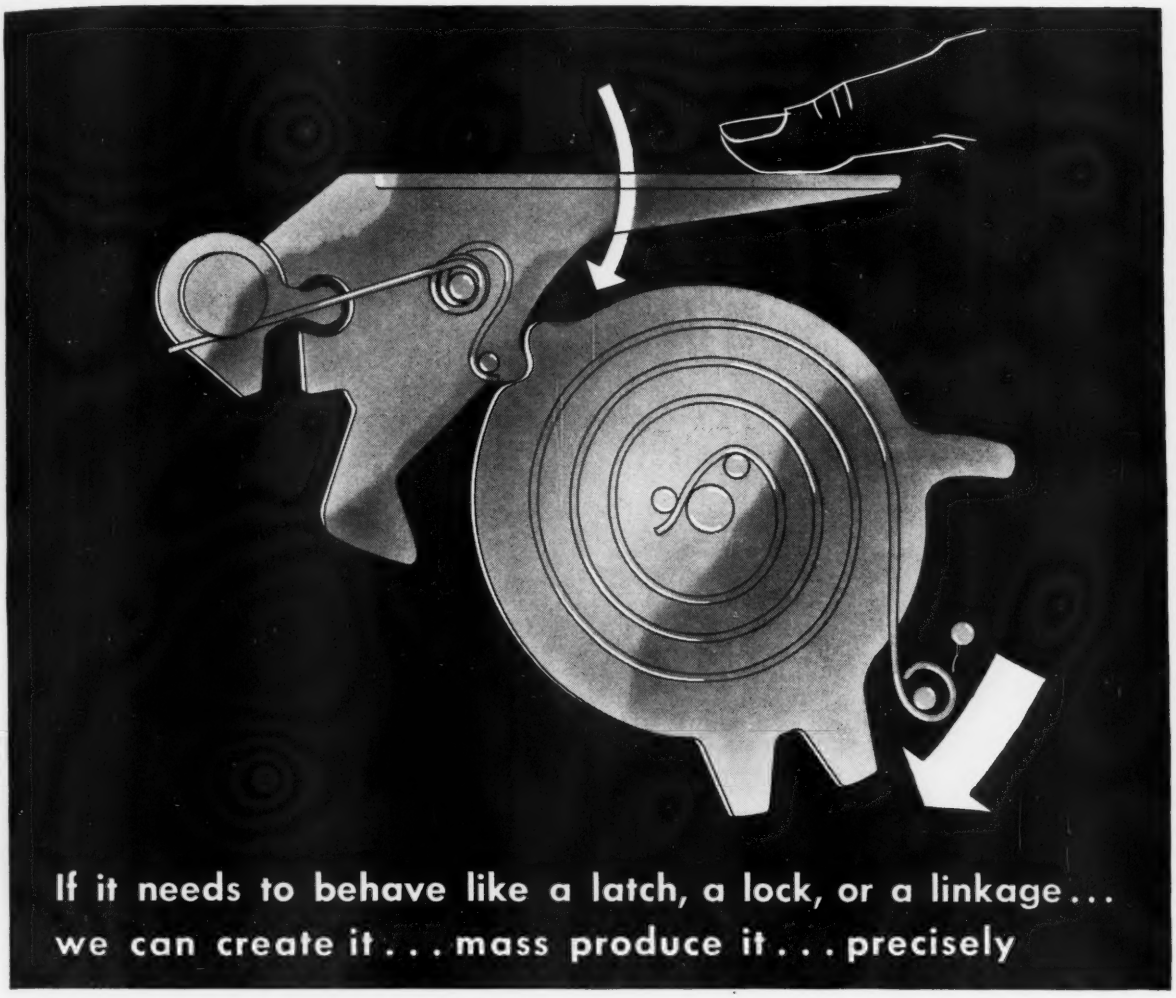

...WITH STAMPINGS!

If a part of your product needs to snap, latch, catch, link, lock, spring or trip—if it needs a mechanical motion to promote *safety*, convenience, performance or salability, Standard is the place to go.

We can make these devices so that they will work by spring, cam or lever. We can make them rigid or freely operated . . . to slide, swing, rotate or to produce any one of an endless variety of motions.

Sometimes they must be concealed, or withstand excessive vibration, or be tamperproof. For example, we have built a great deal of extra *safety* into the door locking devices of many, well-known automobiles.

Out of our experience with light and heavy stampings we have developed a variety of techniques—more modern stamping methods—more closely controlled assembly methods—to hold such devices to unusually close tolerances.

Does this careful approach to latches, locks and linkages suggest a way to improve your product? If so, we'd be pleased to discuss your application . . . any time.

THE REID DIVISION OF *The Standard Products Co.*

THE MARK OF A SUPERIOR PRODUCT

DEPT. C, GENERAL OFFICES: 2130 WEST 110 STREET • CLEVELAND 2, OHIO

WE MAKE MOTIONS

• **Lockheed Aircraft Service, Inc., Subsidiary of Lockheed Aircraft Corporation** . . . Aerovias Brazil and Avianca, the Columbian air line, have awarded Lockheed Aircraft Service contracts for the major overhaul of DC-4's.

• **McDonnell Aircraft Corporation and Aluminum Company of America . . .** A successful fabrication—on an experimental basis—of forge-tapered aluminum wing spars has been made. This new method of wing-spar fabrication provides a bulb of aluminum in the web of what is otherwise an I-beam-type extrusion. The extrusion is then forged in such a manner that the bulb is progressively flattened. After forging, the web tapers from 10 in. at one end to about $15^1/_2$ in. at the other. During the processing, Alcoa's Lafayette Works extrudes and the Cleveland Works forges the metal; McDonnell rough machines the forge-tapered extrusion and returns it to Alcoa for heat-treatment and stretching, after which the extrusion is sent back to McDonnell for final machining. The length of the spar is slightly over 13 ft.; its final weight is 117 lbs., representing about a 50-lb. reduction in weight of the fighter plane for which the spar is being fabricated. McDonnell, where the idea was conceived, has applied for a patent on some features of this fabrication method.

• **Meletron Corporation . . .** A new pressure switch, said to be more resistant to high-frequency vibration than former models, has just been put into production. Known as Model 431, the switch is being used to control automatic selection of fuel tanks on the Northrop F-89 Scorpion. Other applications of Model 431 include installation across fuel filters to control the alcohol deicer pump; to control fuel-tank pressurization; and in jet-engine fuel-control systems.

• **Minneapolis-Honeywell Regulator Company . . .** A new explosion-proof magnetic fuel valve was announced by the Aeronautical Division. Designed to meet electrical, mechanical, and operational requirements of military specifications (#MIL-V-5781 USAF, 14 June 1950), the new valve provides instantaneous "on-off" flow control demanded of hydraulic lines conveying petroleum products or other noncorrosive liquids. Spring-loaded valve action closes the valve immediately in the event of power failure. The valve is applicable to fuels containing 0 to 30 per cent aromatics and is said to operate properly over the entire temperature range of 65° to 165°F.

• **The Parker Appliance Company . . .** Snyder Aircraft Division, Air Associates, Inc., has been appointed distributor for Parker precision aircraft O-rings.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation . . .** A new school for training new employees for their jobs was scheduled to have been opened last month. It is located in a four-story building in Hartford and is to supplement the facilities of the Training Department at the East Hartford plant.

• **A. V. Roe Canada Limited . . .** A new factory for the production of the Avro Canada Orenda turbojet engine now under construction at Malton, Ontario, will be in operation toward the end of this year, according to an announcement.

• **Solar Aircraft Company . . .** The Washington, D.C., office is now located in Room 1011, Cafritz Building, 1625 "I" Street, N.W.

• **Stratos Division, Fairchild Engine and Airplane Corporation . . .** Stratos Model S60-10 cabin superchargers are to be used to pressurize the new Lockheed Constellations bought by Avianca, the Columbian air line.

• **Union Carbide and Carbon Corporation . . .** Copies of a new 12-page booklet on "UCON Hydrolubes," which presents in detail their physical properties and advantages as fire-resistant hydraulic fluids, are now available.

• **Westinghouse Aviation Gas Turbine Division, Westinghouse Electric Corporation . . .** The J40, designed by Westinghouse engineers under the guidance of the Navy's Bureau of Aeronautics, has successfully completed its ground tests that qualify it for quantity production.

• **Westinghouse Electric Corporation . . .** An electrical "co-pilot" has been developed which will, according to claims, guide the Lockheed F94C fighter plane in which it is to be installed through loops, rolls, and other combat maneuvers with split-second accuracy. This automatic pilot with "unlimited maneuverability" was developed by Westinghouse engineers in cooperation with the flight engineers of the Air Materiel Command's Armament Laboratory, Control Equipment Branch. The jet-plane version of the autopilot is said to weigh one-third less than that of conventional automatic pilots. It is radio-controlled and can therefore serve to direct the flight of guided missiles and pilotless aircraft. . . New synchronous and nonsynchronous control equipment for low-capacity, spot-type, resistance-welding machines is now available from Westinghouse.

• **Wright Aeronautical Corporation, Curtiss-Wright Corporation . . .** The 540,000-sq.ft. facilities of the New Jersey Worsted Mills, Garfield, N.J., has been purchased in line with Wright's new controlled expansion program. The engine manufacturing subsidiary of Curtiss-Wright will take immediate possession of approximately one-half the area and the remainder within a year. This 26-acre tract affords 400,000 sq.ft. of ground-floor area, in addition to basement space and a three-story warehouse. Wright's Wood-Ridge plant has a total floor space of 2,290,000 sq.ft., covering over 52 acres, and new construction is under way to provide additional floor space there. . . The Wright R-1300 aircraft engines are to be built by Kaiser-Frazer Corporation in its Detroit Engine Division. Tooling and plant conversion began immediately upon consummation of the contract. The first engines are scheduled for delivery early in 1952. The two corporations concerned, Kaiser-Frazer and Wright, have signed a technical-assistance contract and a licensing agreement.

Personal Aircraft Meeting Canceled

During the past 6 years the Institute has held Annual Meetings to discuss problems pertinent to the design of personal aircraft. These meetings have been held in Detroit and Wichita. The Wichita Section has recently been the prime mover in their organization.

Because of the general pressure and in view of the somewhat unsettled conditions in the light-plane industry caused by current trends in World affairs, the I.A.S. Meetings Committee and the Wichita Section have agreed to cancel the meeting tentatively scheduled for May, 1951.

There is no thought that this type of meeting should be abandoned. It is expected that conditions will again be favorable for resumption of these programs in the Spring of 1952.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th St., New York 21, N.Y.

Hummingbirds that boss Eagles . . .

In the realm of the airman, where tiny high-precision motors regulate intricate systems of instrumentation and control, Kollsman miniature motors have no peer.

In fact, these accurate and dependable units have been a Kollsman specialty for years.

Yes, throughout aviation history—where hummingbirds have had to boss eagles—Kollsman has won renown for doing the job inimitably well.

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for precision and dependability look to

KOLLSMAN

INSTRUMENT CORPORATION

Elmhurst, New York • Glendale, California

Meet Your Section Chairmen

Robert D. Gilson

Hagerstown Section

"As happened to so many fellows of my age," writes 35-year-old Robert D. Gilson, "I was bitten by the aeronautical bug spread by Lindbergh's transatlantic flight and thenceforward deviated from an interest in my father's electrical engineering career to making model airplanes, joining school aero clubs, and reading avidly all aeronautical accomplishments from the facts of Alcock and Brown to the fiction of Tom Swift. My first real flying was experienced in our college Glider Club at the end of a rope in a primary glider behind an Essex 'hot-rod.' We naturally spent more time in the rebuilding of the glider than in the flying of it."

A native of Pittsburgh, Mr. Gilson attended the secondary schools of that city. In 1933, he matriculated at Carnegie Institute of Technology, from which he was graduated in 1936 with a B.S. degree in Mechanical Engineering with an Aeronautical Option. Almost as soon as Carnegie Tech's "sheepskin" was safely in his possession, he went to work for The Glenn L. Martin Company in the capacity of an Aerodynamicist concerned with flight test analysis and new design performance. Four years later, in 1940, he was transferred to stress analysis on PBM-3 hulls and then to the B-26 wing. He left Martin early in 1943 to become Project Stress Engineer on the XP-75 and the P-75 fighters, Aircraft Development Section, Fisher Body Division, General Motors Corporation. Late the following year, he returned to Martin, where he remained as Chief Flight Test Engineer until his resignation in June, 1948.

Mr. Gilson says: "I took on the job of setting up a farm-equipment repair business in my wife's home town of Arlington, Ga., but in the interest of financial security for my family returned to aircraft work" at the Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation; this was in April, 1949. He is currently employed as a Structural Engineer, with his accompanying worries centered chiefly around the stress analysis and struc-

(*Continued on page 98*)

F. A. Cleveland

Los Angeles Section

In 1930, 7-year-old F. A. ("Al") Cleveland received a subscription from an aunt for *Popular Mechanics* magazine. This proved to be the turning point in young Cleveland's life, for it redirected his aim in life from the ultimate of being a streetcar motorman to that of becoming an engineer. The subscription expired in due time, but his interest in engineering did not. The aeronautical restriction to the general engineering field arrived a few years later in the form of a series of balsa airplane models. Nowadays, he looks back with considerable envy at the design conditions prevailing during that particular period of aircraft construction. Representing the complete antithesis of that period is his present position as Research Group Engineer in the Preliminary Design Division, Lockheed Aircraft Corporation, which places on him the responsibility for a preliminary design study being conducted under an Air Force contract.

Born in Dayton, Ohio, in 1923, Al Cleveland's family gradually gravitated westward, arriving in California in time for his high-school and university work. He took his degrees, an A.B. in Mechanical Engineering and an M.A. in Aeronautics, at Stanford University, completing the necessary prerequisites for both degrees in a 4-year period with the help of summer-school attendance. The

(*Continued on page 98*)

John W. R. Drummond

Montreal Section

John William Roberts Drummond, Assistant to the President of Canadian Pratt & Whitney Aircraft Company, Ltd., is in charge of all sales and service activities of the company. This includes the "sales and service" on Pratt & Whitney engines, Hamilton Standard propellers, and Sikorsky helicopters. He was formerly Sales Engineering Supervisor, same company.

Mr. Drummond was born in Montreal, Quebec, Canada, on November 15, 1914. He attended Westmount High School and in 1933 matriculated at McGill University from which he was graduated in 1938 with a B.S. degree in Mechanics.

During his student days at McGill, in 1936 to be specific, Mr. Drummond was first employed by Canadian Pratt & Whitney. Finding that he liked aeronautics well enough to make it his life's profession, he found work with Trans Canada Airlines as Production Engineer immediatey upon his graduation from McGill. While he was with T.C.A., he was in charge of the work control for the repair base. After 2 years with T.C.A., he was re-employed by Canadian Pratt & Whitney as a Sales and Service Engineer. The following year, in 1941, he transferred to a subsidiary concern, Canadian Propellers, as a Tool and Production Manager in charge of tool design. In 1943, he was back again

(*Continued on page 100*)

Last Call for Roster Listing

In order that the *1951–1952 I.A.S. Roster of Members* be as complete and accurate as possible, a last call is being issued for required data concerning present employment and titles and preferred mailing addresses of I.A.S. members.

Some members have failed to send in their completed roster data cards. Make sure that your data card is filed immediately. This is your last opportunity to be correctly listed in the *1951–1952 I.A.S. Roster*.

for Dynamic
or Static Stress Analysis
New, Low Cost

Portable Polariscope

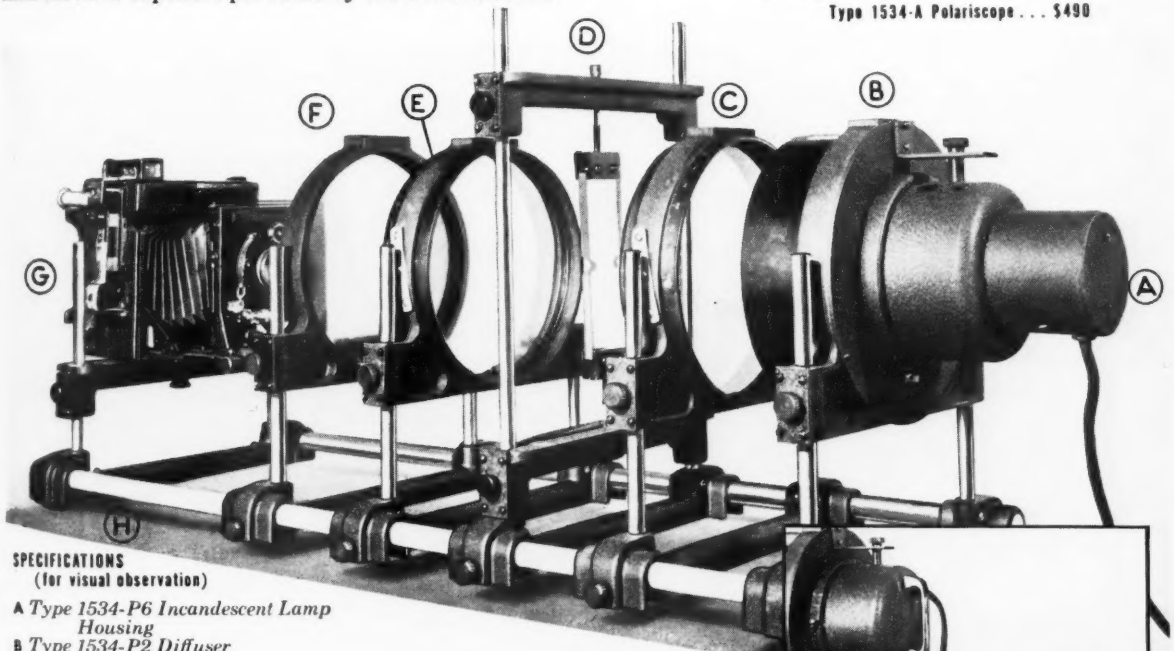
Formerly the apparatus required for either visual or photographic observation of photoelastic stress . . . either static or dynamic . . . was cumbersome, very expensive, excessively bulky and heavy.

The recently announced G-R Type 1534-A Polariscope, with its associated STROBOLUME high-intensity light source, has made possible the elimination of all of these difficulties. Formerly, photographic exposures ran into minutes; the bench set-up accordingly had to be carefully designed to minimize vibration in its many parts. The G-R Polariscope consists of an assembly of light rods, supports and disc mounts, this lightness being made possible through the 40-microsecond exposure provided by the STROBOLUME.

The G-R POLARISCOPE FEATURES

★ *Unusually large field of 8 inches.*
★ *Very simple means for making instantaneous photographs of dynamic stresses . . . requires only standard camera with f/4.5 lens.*
★ *Time exposures no longer necessary . . . the* STROBOLUME*'s flash duration is only 40 microseconds . . . unusually short wavelength light . . . very high sensitivity.*
★ *Complete portability . . . weighs only 32 pounds . . . quickly assembled and dissembled . . . ideal for lectures and other demonstrations.*
★ *Easily removed quarter plates and polarizers.*
★ *Simplified replacement of damaged elements . . . snap-in assembly.*
★ *Convenient to use . . . horizontal and vertical adjustments over wide ranges . . . simpler than an optical bench.*
★ *Very low cost.*

Type 1534-A Polariscope . . . $490

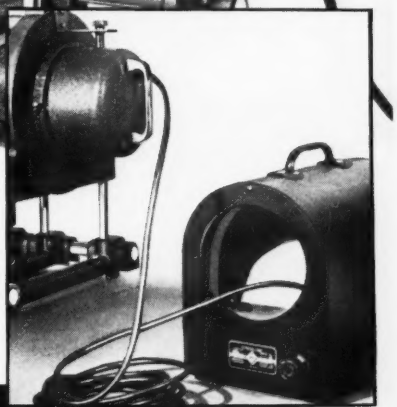


SPECIFICATIONS
(for visual observation)

A *Type 1534-P6 Incandescent Lamp Housing*
B *Type 1534-P2 Diffuser*
C *Type 1534-P1 Polarizer*
D *Type 1534-P3 Strain Bridge for Sample*
E *Type 1534-P1 Analyzer*
F *Type 1534-P5 Filter*
G *Type 1534-P4 Camera Bridge (Camera not supplied)*
H *Type 1534-P7 Shafts (furnished 36 inches long)*

(Accessories required for photography)

A Type 1532-A STROBOLUME. *Standard camera, preferably with ground-glass focusing, with f/4.5 or faster lens. Wratten No. 75 front-of-lens filter recommended to reduce effects of normal room lighting.*



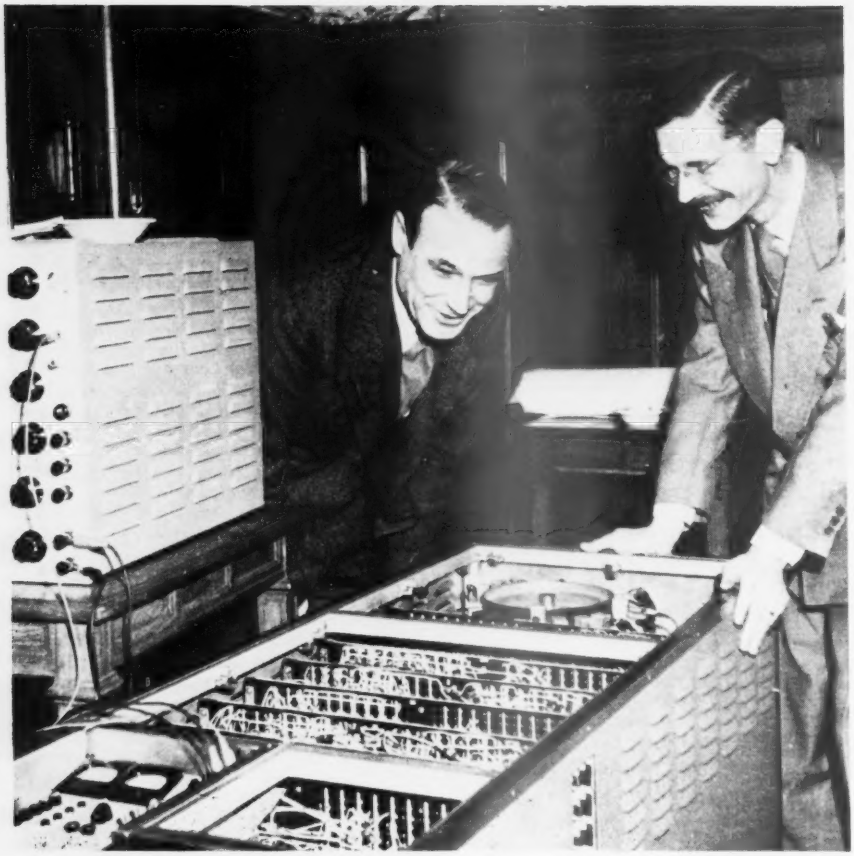
The Type 1532-A STROBOLUME

in place, with its power supply at the right. One knurled nut readily removes the STROBOLUME *lamp for substitution of the standard lamp for incandescent visual observation.*

TYPE 1532-A STROBOLUME . . . $245

GENERAL RADIO Company
275 Massachusetts Avenue, Cambridge 39, Mass.

90 West Street NEW YORK
920 S. Michigan Ave. CHICAGO
1000 N. Seward St. LOS ANGELES



MADDIDA, a compact portable electronic computer designed by Northrop for the U.S. Navy, has recently been acquired by the Stevens Experimental Tank (see story on page 6). This is a thoroughly legitimate Solution-in-search-of-a-Problem concept.

First Things First

Recently, a meeting was held by a committee that had been set up some years ago to consider postwar problems of one of the branches of the Government. The group was made up of public-spirited citizens who had a real interest in matters that had come before it and whose contributions had been substantial.

But this time things weren't quite the same. Questions that had been of vital interest a year before, no longer seemed of any importance. The emphasis had shifted away from "postwar" problems. In current "Washingtonese" the Committee's Frame of Reference had collapsed. Wisely, it agreed to disband. As one of its members suggested, it had become a Solution looking for a Problem.

Unfortunately, in our Alice-in-Wonderland economy such a situation is all too often the rule rather than the exception. The theory seems to be that the mere existence of a board or committee (with a suitably impressive list of Chairman, Vice-Chairman, and other

Editorial

functionaries) will automatically attract problems like bees to a honeypot and will guarantee to solve them.

Possibly, the widespread use of electronic computors has led us to accept the Solution-seeking-a-Problem idea too easily. It is comforting indeed to know that these "magic brains" are standing by to whittle practically any problems down to a manageable size. But if "Mad Ida," and her sisters and her cousins and her aunts, develop neuroses and blow out their fuses straining to disgorge solutions for which problems are lacking—nobody minds. A collection of vacuum tubes and coils of wire can be torn down and made over into television sets, or hair driers, or something equally useful.

To tie up or to waste human energy and talent is infinitely worse. To try to keep boards, committees, or commissions alive in the hope that they can find something to do to justify their existence is morally indefensible. The tear-down technique must be applied ruthlessly to such organizations no matter how effective they may have been in the past. The moment they outlive their usefulness, they should be scrapped and their components released for other purposes.

Unfortunately, especially in Government, organizations tend to become impressed with their own importance and vigorously resist disintegration. Each one builds up its little empire and fights to the death any attempt to take it apart, even though it has lost its original purpose. This may account for much of the current confusion in Washington. Things that used to be simple have become tremendously complicated, largely because of the number of organizations that must be consulted before any action can be taken on anything. Possibly, continual checking and rechecking is necessary, but we have reached the point where each stage should be examined objectively and most critically with an eye toward its elimination. We have already gone a long way toward organizing ourselves to death. If we do not recognize this fact and do something about it, our whole social and economic structure may collapse of its own weight and carry away with it all the things that we are now struggling to keep.

Engineers in particular must avoid the Solution-looking-for-a-Problem hazard. At the present time, the aggregate of real problems for which solutions must be found is mountainous, and the supply of men competent to attack them is small indeed.

The I.A.S. is doing all it can to improve the quality and quantity of technical people to meet the demands of the aircraft industry. But we are all in for a long, hard pull. As many of you know, particularly those who have come to us for personnel, good people are extremely scarce now, and the outlook for the immediate future is not at all encouraging.

It is therefore of the utmost importance that we use all available talent as effectively as possible. No one can afford to knock down straw men to prove his individual importance. No one can afford to belong to organizations that meet for the sake of meeting or to struggle to keep organizations together simply for the sake of keeping them alive. Every activity must serve some useful purpose. There never was a time when it was more vital to utilize all available man power to deal with the important problems in the order of their importance.

Trite as it may sound, we must all face up to the necessity of doing First things First. To do it any other way would be silly. We haven't the time.

S. P. J.

Application of Rocket Power to Aircraft

HOWARD R. MOLES*

Reaction Motors, Inc.

ABSTRACT

The application of rocket power to past, present, and future types of aircraft is described in this paper. Liquid-propellant rockets for man-occupied aircraft receive the major attention.

The characteristics of rocket power plants are first presented. A brief history of the application of rocket power to missiles, from the crudest beginnings in the early 1200's to the present day, is given. The more common propellants for aircraft application and methods of storing low-temperature boiling propellants are described.

The major advantages of a rocket power plant in an aircraft are listed, and a typical arrangement of a pump-fed rocket power plant is described. Finally, the question of whether an effective military rocket-powered interceptor can be built today is examined.

DISCUSSION

A ROCKET-POWERED PROPELLED VEHICLE is one that carries within its structure the entire propulsive mass to be expelled. There are basically two types of rocket power plants—those employing solid propellants and those employing liquid propellants. The time allocated for this paper is not adequate to cover the entire field of rocket power plants. Therefore, this paper will deal in general with the application of liquid propellants.

An aircraft is any weight-carrying structure for navigation of the air. In the case at hand, we will limit our discussion to aircraft supported by the dynamic action of the air against its surface—in other words, winged aircraft. There are various classifications of the application of rocket power to aircraft. Since the two primary characteristics of rocket power plants are low specific weight and high specific propellant consumption, we must look to short durations and/or high thrust for the more promising applications of rockets. Other characteristics also distinguish the rocket power plant and may give clues to profitable applications. Among these are the relative independence of the rocket on ambient conditions and relative simplicity and cheapness.

In the region of high thrust and short duration, the rocket booster, or ATO, represents an application that has the catapult as its main competition. In this field, the number of launchings from a given location, rapidity of launching, requirements for portability, end speed, etc., will govern the choice between the two methods. The duration at which other types of power plants enter the picture depends on many other factors—i.e., state of development, flight path, speed, thrust program, etc. If it is desired to operate at altitudes substantially devoid of oxygen, the rocket must, of course, be used. Here, there is no known competitor. In the field of guided missiles, the relative cheapness of the rocket engine tends to extend the endurance at which it is most economical. Recently, attempts to produce other "expendable" types of power plants have met with some success and offer additional competition. With the above considerations in mind, rocket power plants appear to have usefulness for the following purposes:

Primary Power Plants

(1) Long-range supersonic missiles (surface to surface).

(2) Antiaircraft missiles (surface to air)

(3) Air-to-air missiles.

(4) Air-to-surface missiles.

Presented at the Flight Propulsion Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Chief Engineer.

(5) High-performance, limited duration, manned aircraft.

Auxiliary Power Plants

(1) Guided missile "boosters."
(2) ATO units.
(3) Superperformance at altitude.
(4) Specific "flash" performance to meet a tactical problem.
(5) Starting ram-jets.
(6) Helicopter rotating wings.
(7) Auxiliary power sources.
(8) Jet pumping.

You are familiar with most of these uses. However, a few words on the jet pump is perhaps necessary to explain the application in mind.

Fig. 1 is a sketch of a jet pump using a rocket power plant as the transfer or power-supplying medium. The jet pump operates on the principle of energy transfer from the high-velocity primary fluid to the low-velocity secondary fluid. The kinetic energy of the resulting mixture is converted into a pressure head by the diffuser. This process finds application in the following fields that are characterized by simplicity, compactness, and low pumping efficiency: (1) air ejectors for wind tunnels or large-capacity evacuators; (2) thrust augmenters; (3) combustion chambers where high velocity mixing and combustion is necessary; (4) air pumping in intermittent boundary-layer control systems. The application of rocket power to jet pumping as applied to boundary-layer control is a good use of rocket power, since it requires the moving of a large volume of air from the flap area on the wing of an airplane and exhausting it over the aileron area and is used for a short period of time during take-off and landing.

The application of rocket power is not a new subject. It is recorded that, in the early 1200's, the Chinese had arrows powered by rockets. In the early 1800's, Great Britain experimented with projectiles powered by solid propellants. It was thought for a time that this weapon would find extensive use in field artillery. However, the control and accuracy were poor, and the development was not carried to a conclusion. Various groups worked on rockets throughout the world. The Germans flew their first successful rocket-powered piloted aircraft in the early 1940's. You are all familiar with the early work in rockets in this country in the 1900's. However, the rocket companies in operation today were formed in the early 1940's. In the United States, the following airplanes have flown either with rocket-assist take-off or with rocket power plants as the sole source of power: XP-73, PBY, PB2Y, PBM, A-20, B-25, B-45, B-29, C-47, P-51, F-80, D-558-2, X-1, and some classified projects. All of these airplanes have been subjected to extensive testing. Although the rocket power-plant installations have all been experimental in nature, no serious accidents have occurred to my knowledge. The X-1's alone have made over 200 rocket-powered flights.

As has been stated, rocket power plants are operated either on solid- or liquid-propellant systems. In both cases, the propulsion energy is provided by a chemical reaction, which in most cases, but not always, is a combustion reaction, such as burning of a powder. Solid (powder) rockets by far anteceded liquid-propelled rockets.

Liquid propellant systems can again be subdivided into monopropellants and bipropellant systems. The former are a liquid version, so to speak, of solid powders; they are made up of one liquid chemical compound or a homogeneous liquid mixture of compounds which contains all the necessary ingredients for the reaction. With bipropellant systems on the other hand, two liquids—the fuel and the oxidizer—are required for the reaction giving the propulsion energy. Although, off-hand, bipropellant systems look more complicated, they usually turn out in practice to have certain advantages with respect to safety, storage, handling, and flexibility.

Before enumerating the most widely used liquid-propellant combinations, it may be appropriate to list briefly the requirements of a suitable propellant combination.

Specific impulse is a measure of the thrust obtainable from the unit flow-rate of the propellant combination. Clearly, it should be as high as possible.

The average density determines the size of tanks; high densities are, therefore, to be preferred in most applications.

Good ignition characteristics are necessary for smooth starting and operating of the rocket.

Freezing points should be low in order to permit operation in cold weather and at high altitudes without auxiliary heating; on the other hand, the boiling point should be high because otherwise high-pressure tanks are required for storage and in the aircraft itself.

Also, the propellants have to be chemically stable and must not be unduly sensitive to thermal or mechanical shock.

In addition, they should be compatible with the usual materials of construction, should be nontoxic and easy to handle, should not cause difficulties in shipping and storing, should be available in large quantities at a low price, and should not be strategic materials.

This long list of requirements includes only the most important items, and you will therefore readily under-

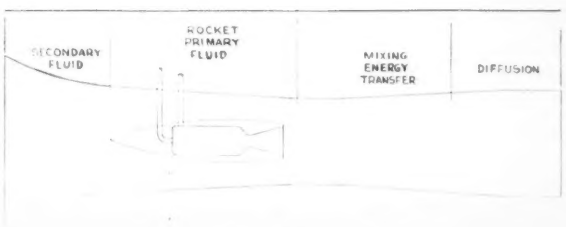


Fig. 1. Jet pump.

stand that, up to now, no propellant combination has been found which is satisfactory in every respect. Rather, the principal propellant combinations being presently employed always represent some compromise, one or the other combination being chosen according to the special application intended.

Security regulations do not permit a discussion of more recent developments toward combining as many as possible of the desirable characteristics. However, such a discussion would be of interest to fuel specialists only. My purpose is rather to describe briefly those propellant combinations on which most of the presently used rocket power plants operate.

With few exceptions, these propellants are materials that have already been used in reciprocating engines, the essential difference being that the oxidizer is being employed in much more concentrated form. For example, liquid oxygen is commonly used instead of the gaseous and diluted oxygen contained in the air, because in this way the thrust per unit weight of propellant is increased simultaneously with the density. The trend toward fuels having a high combustion value is to be traced to the same reasoning. From this short explanation, you will readily conclude that the principal fuels are liquid organic materials with a high combustion value (such as gasoline, JP3, and alcohol), whereas the oxidizers are such materials as liquid oxygen or fuming nitric acid, which also contain oxygen in concentrated form. Consequently, such propellant systems as alcohol-lox, gasoline-nitric acid, or other combinations of the above materials are commonly encountered in rocket power-plant applications. Other propellant systems, such as aniline-nitric acid, are being used because they ignite spontaneously and therefore do not require separate provisions for ignition. Finally, certain liquid monopropellants, such as hydrogen peroxide, are employed for special purposes: for instance, for driving turbines and pumps. Hydrogen peroxide furnishes the propulsive energy by decomposition and is, therefore, an example of a propellant whose action is not based on combustion but rather on decomposition.

This short discussion of propellants can, of course, give you only some idea of the problems encountered and the general trends being followed in the selection of suitable propellants. However, I feel that I cannot enter into more detail without deviating too much from the purpose of my paper, which is the application of rocket power to aircraft.

There are two broad classifications of systems to feed the propellant into the combustion chamber. One is called the pressurization system, in which the main propellant tanks are placed under pressure. The other involves pumping the propellant from the tanks to the combustion chamber. The pressurization system is only economical from a weight consideration at low thrust levels and for short durations. However, its simplicity is attractive. The pumping systems will be covered later in this paper.

The method of storing liquid oxygen or any low-temperature-boiling propellant has been the subject of a great deal of discussion. In the following, only liquid oxygen will be discussed; however, the same principles apply to any low-boiling-point propellant.

Liquid oxygen is a perishable commodity. Because of its extremely low boiling point, $-297°$F. at 1 atmosphere, it boils away rather rapidly from tanks and other containers. This boil-off goes on whether the tank is open or closed, and, in fact, tanks used for liquid oxygen storage must be provided with a vent, otherwise the pressure built up by evaporation will eventually go high enough to destroy practically any tank.

In general, the evaporation of oxygen from a storage tank cannot be prevented, but by suitable insulation it can be reduced to as low as 2 or 3 per cent of tank capacity per day, and even less, depending on the type of insulation used and the size of the unit.

In the laboratory, the well-known vacuum-jacketed Dewar flask has been successfully used for over half a century for storage of various liquefied gases. However, it is not suited for anything but extremely small sizes because of its fragility.

For larger capacities, metal vacuum containers are used. These are generally made of two copper spheres, one inside the other, the jacket space being evacuated and the walls highly polished to reduce radiation losses. While these containers are not so fragile as the glass flasks, they are still delicate and must be handled with caution.

On the industrial scale, the insulation is frequently applied to the tank in a manner of boiler lagging—that is, a thick layer of 85 per cent magnesium, asbestos, or a similar substance. Unfortunately, this method is not very effective unless the insulating material is built up to a considerable thickness, say, about 1 ft. thick; even then, the results leave much to be desired. The most successful industrial tanks have been those where a reasonably thin layer of lagging material is used in combination with a vacuum.

In application to aircraft, up to the present time, little effort has been made to utilize any form of insulation; rather, we depend on quick timing to keep the oxygen in the tanks from evaporating unduly. This method is suitable for experimental use, but is not suited to stand-by requirements where a plane must be kept in readiness for instant use for any length of time. For this purpose, a lightweight compact tank is required, with an evaporation rate of about 10 per cent per day. The evaporation rate could, of course, be made much lower than this, but the weight and space limitations in aircraft require that a compromise be obtained between evaporation rate and tank weight. A tank that loses 10 per cent per day could be serviced every 12 hours, at which time only 5 per cent of its contents would have to be replenished.

The design of such a tank along the well-known principles of heat insulation does not present any radical problems. It is simply a problem of adapting existing industrial designs to special requirements of air-

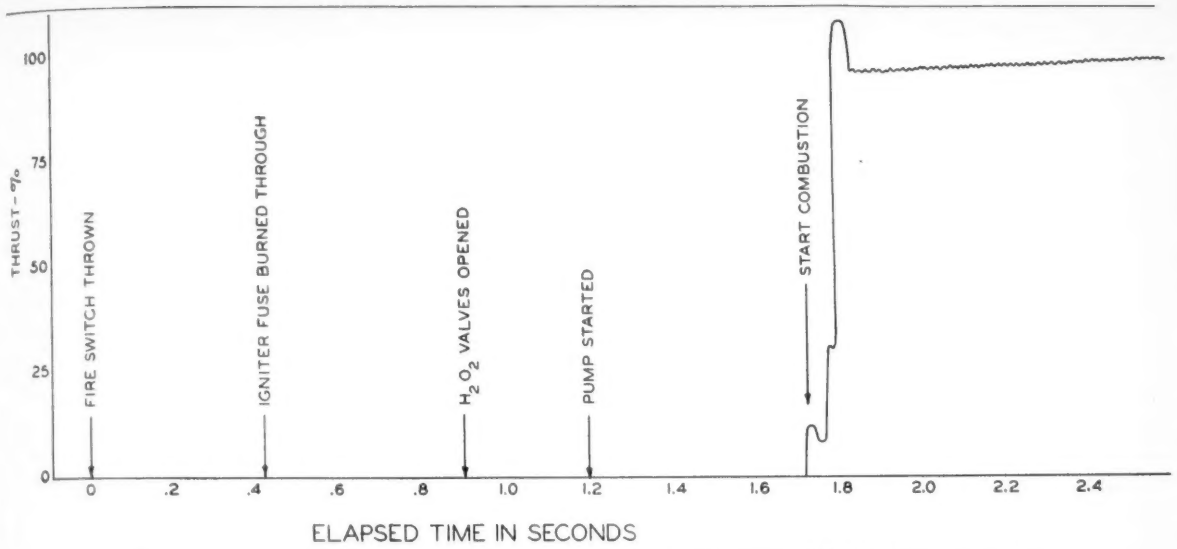


FIG. 2. Rise of thrust vs. time for a typical run of the alcohol-liquid oxygen 20,000-lb. thrust power plant.

craft application. Experimental work is being conducted along these lines.

ADVANTAGES OF ROCKET POWER PLANTS

Let us now consider and review briefly some of the major advantages of a rocket power plant installed in an aircraft.

(1) The ceiling, speed, and climb performance are limited only by the amount of propellants that it is possible to carry in the aircraft.

(2) The dry weight of a rocket power plant is practically independent of the altitude for which it is designed to operate. In other words, the dry weight of the rocket power plant does not increase with altitude.

(3) The propulsive efficiency increases with the increase in airplane speed up to the point where the airplane speed equals the rocket exhaust velocity.

(4) The change of thrust with altitude is small as compared to air-breathing propulsion systems. The maximum airplane speed and rate of climb increase phenomenally at higher altitudes.

(5) The dry weight of the rocket is about one-twentieth the weight of a reciprocating engine when compared on a thrust basis.

(6) The maximum velocity of the rocket-powered aircraft is limited only by the density of the air in which the airplane is traveling.

(7) Rocket power-plant developments are in sight which will raise our present propulsive efficiencies.

(8) It is generally more efficient to use a large rocket that is high thrust for a relatively short duration and build up the speed of the airplane to a high velocity and obtain the range while gliding at or above sonic speeds.

(9) The rocket power plant has a high rate of thrust build-up. A curve will be shown later amplifying this point.

(10) The cross section of the rocket power-plant combustion cylinder is small compared with any other means of supplying the same amount of thrust.

With regard to the power range or total thrust available, there are no visible limits as to the size or total thrust output that can be built, especially using liquid propellants. Many of the problems in the small rocket power plant decrease in magnitude as we go to larger sizes. For example, only that portion of the flame which comes in contact with the cylinder walls need concern us. Since the volume of the cylinders for a unit length increases as the second power of the increase in diameter while the circumference increases as the first power, the cooling problem thus becomes less critical in large cylinders.

Fig. 2 is a plot from test information of the actual sequence of events during the starting of a Reaction Motors, Inc., 20,000-lb. liquid oxygen-alcohol cylinder. You can see from this plot that, from the time the first fire switch is closed until the combustion chamber has reached 95 per cent of full thrust, approximately 2 sec. have elapsed. Also, the time from when combustion is first started until the combustion chamber is up to 95 per cent of full thrust is less than 0.2 sec. A stable state of operation is obtained in the rocket after a few seconds' operation.

It is desirable to locate the propellant tanks near to the center of gravity of the airplane. The total propellant load is a high percentage of the entire weight of the airplane. Therefore, to avoid trimming during flight, the propellant should be located as near the center of gravity as is possible. The rocket engine is of light weight, and therefore its location in the airplane has a relatively small effect on the center of gravity of the plane. It is desirable to locate the rocket engine well aft in the fuselage or wing. This requires the minimum of ducting aft of the rocket. It is highly desirable and important that all of the components of the rocket power plant be assembled and installed as a

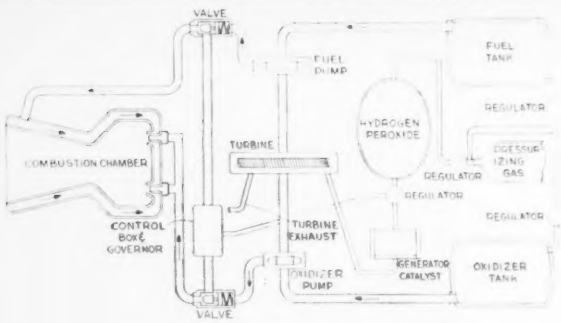


FIG. 3. Typical rocket engine.

packaged unit. This decreases line losses, improves stability, and ensures more reliable operation.

The fact that the rocket carries its own oxidizer means that an air-intake duct is not necessary. The only ducting necessary is for ventilation air and for cooling specific accessory units. The temperature in the vicinity of the combustion cylinders is below the boiling point of the fuel used, since the cylinders are usually regeneratively cooled. The space for instrumentation in the cockpit of any airplane is, of course, at a premium. Fortunately, few instruments are required for normal operation of a rocket motor. It is necessary to measure the combustion chamber pressure and various manifold pressures.

A misconception that is being dispelled as familiarity with rocket power plants increases is that things happen so fast that the pilot can do nothing to correct an event before it happens. The controls in the cockpit for a rocket motor are relatively simple. They are generally electrical in nature, consisting of switches to turn on the pressurization gas to the propellant tanks, energizing the governor, closing the firing switch, and selecting the level of power output by a throttle.

Fig. 3 shows a typical arrangement of a pump-fed rocket power plant. At the right, there is a gas pressurization bottle that may contain either nitrogen or helium and which is used to pressurize the fuel and oxidizer tanks. The pressure placed in the propellant tanks is only for the purpose of increasing the suppression heads on the pumps, and, in the case of some aircraft applications, expulsion bags are used in the propellant tanks. The propellants are pumped from the tanks to the combustion chamber as shown in the diagram. The pressurization bottle also supplies pressure to the hydrogen peroxide tank. The hydrogen peroxide is fed into the generator. The products from this generator are used to drive the turbine, which in turn drives the fuel pumps. The control box shown is used for controlling the amount of hydrogen peroxide fed to the generator and controls the propellant valves. The sequence of operations in starting the rocket motor is as follows. The governor or control box opens the valve between the peroxide tank and the generator, allowing hydrogen peroxide to be decomposed by the catalytic action of the manganese dioxide in the generator. The products coming from the generator are superheated steam and free oxygen. These drive the turbine, which in turn drives the propellant pumps. The exhaust from the turbine is shown as being dumped overboard. However, in most applications, the energy remaining in the exhaust is used for miscellaneous low-power purposes. The fuel being pumped goes through the propellant valves and lines into the lower end of the combustion chamber and circulates through the jacket to the head of the cylinder and thence through the injector into the combustion chamber. The oxidizer pumped by the oxidizer pump likewise goes through propellant valves and lines, directly into the injector located in the cylinder head.

Ignition in the combustion chamber can be started by several different methods, depending upon the application. If it is for single operation, a squib inserted throughout the exit nozzle of the cylinder is used. If repeat operations are required, a small igniter similar to a combustion chamber employing the rocket propellants are used. In this igniter the ignition is first established by an electrical ignition system.

Fig. 4 is the Reaction Motors, Inc., 6,000-lb. liquid alcohol oxygen engine as installed in the X-1 airplane. The headpiece for this article shows the Bell X-1 airplane.

Rocket power plants can be installed in either the fuselage or as wing units. In adapting rocket power to existing aircraft, it is often more convenient to use wing-tip installations.

Possibilities of Building a Rocket-Powered Interceptor

This brief review of rocket power as applied to aircraft leads us to ask the question, "Can an effective

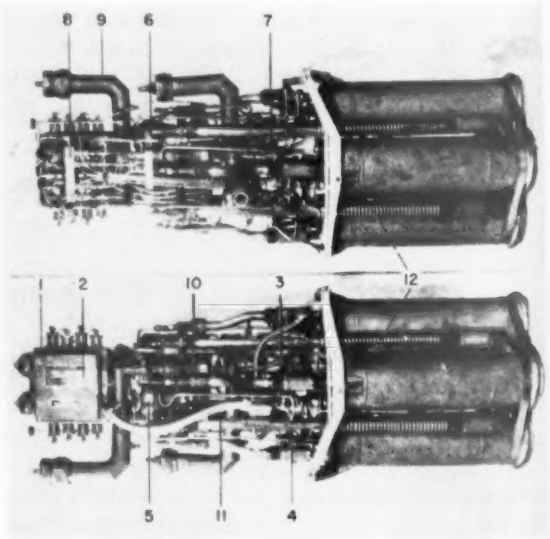


FIG. 4. 6,000-lb. engine assembly: (1) engine control box; (2) ignition coil box; (3) igniter oxygen control valve; (4) igniter; (5) thrust chamber; (6) fuel valve; (7) igniter fuel control valve; (8) nitrogen manifold; (9) oxygen manifold; (10) oxygen valve; (11) fuel manifold; (12) oxygen evaporator coil.

military rocket-powered interceptor be built today?" Let us examine some of the facts that will help us to reach a conclusion. Unmanned aircraft have been exceeding the speed of sound for many years and with many types and configurations of missiles. The fear surrounding the sonic wall has largely been eliminated, or at least sufficient investigation has been made to definitely state that the design problems are not insurmountable. Man has traveled at supersonic speeds with no ill effect to his system. Man has been subjected to higher g loading than it would be necessary to experience in rocket-powered flight. Pressurized control rooms have been in use for many years. The detection systems have had many years of successful operations which will allow the rocket interceptor to operate well above the attainable altitude of conventional airplanes and still be able to detect them for a possible attack.

In view of the foregoing discussion, it may be stated that it is possible to develop a rocket interceptor such as proposed here at a relatively low cost. The problem is primarily one of applying currently available techniques and incorporating into one airplane all items that have been developed to date.

Before we discuss the interceptor that could be built today, it might be well to review briefly what we have that could be converted to intermediary interceptors. The X-1 and other rocket-powered airplanes flying today could be converted to intermediary rocket-powered interceptors that would have performance well in excess of existing military airplanes. They could carry a small warhead and sufficient propellants for a combined climb and cruise at reduced thrust for 20 to 30 min. and still have propellants for a full-power 30-sec. speed run.

Today's rocket-powered aircraft were primarily designed for flight research and, although convertible as mentioned, would not represent the ultimate interceptor airplane. A more advanced interceptor design that presents no extremely difficult problems in design or construction would be along the following lines: A radar antenna would be located in the nose. Directly behind this, sitting in an upright position, would be the pilot. Normal surface controls would be provided. The entire nose could be detachable as a capsule, in case it were desired to lower this portion by a parachute. Back of this capsule would be a section for radio and communication equipment. Then, occupying the major portion of the fuselage compartment would be the propellant tanks, and in the aft end of the fuselage would be located the power plant, which would consist of two cylinders with a total thrust of 26,000 lbs. One cylinder would be a 5,000-lb. thrust unit, and the other cylinder would be a 21,000-lb. thrust unit. In operation, the small cylinder would be started first, and then, after a stable condition is reached, the large cylinder would be started. The airplane would be launched from a launcher operating under the airplane's own power. The gear for launching would remain with the launcher. The airplane would be equipped with skids, either retractable or fixed, for landing, or it could land on any relatively smooth water. The warhead, which is estimated to be about 1,000 lbs., would be carried at the wing tips. A small independent propellant charge would be carried with each warhead to give it a velocity slightly in excess of the aircraft's velocity.

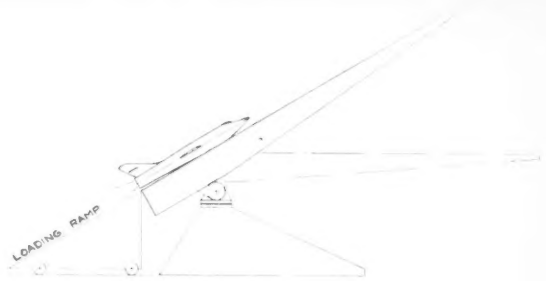


FIG. 5. Rocket interceptor launcher.

The estimated physical characteristics of the airplane would be:

Gross weight	13,000 lbs.
Landing weight	3,500 lbs.
Wing area	100 sq.ft.
Wing span	25 ft.
Fuselage length	30 ft.
Propellants	8,000 lbs.

The estimated performance would be:

Maximum velocity	In excess of 2,000 m.p.h.
Maximum rate of climb	In excess of 50,000 ft. per min.
Ceiling	Above 200,000 ft.
Range	140 miles

It is natural to ask the question: "What will the endurance be?" On this point it should be clearly understood that the conventional idea of endurance does not apply to rocket-powered interceptors. A rocket-powered interceptor would not be for patrol duty. It would be assigned to a specific task. The endurance to cover the 140-mile range would be approximately 6 min.

The tactical mission of this airplane would be "close-in" protection of fixed bases. These bases might be either on land or on the sea. When the Germans were developing the ME 163, they called it the "Home Protecting Airplane." It is apparent from the foregoing that the rocket interceptor has performance far exceeding that of any other type of airplane. The ability of the rocket to take off with zero run and land on skids or in the water would give it a new and varied field of usefulness.

I should like to call your attention to the fact that, because the propellant load is 8,000 lbs. and that the landing weight is 3,500 lbs., the buoyancy of the propellant tanks alone would cause the fuselage to float less than half submerged. The small radius of action and the short endurance indicate that a rocket interceptor

should be operated from fixed bases at key points or from ships guarding a strategic base. A launching ramp, as shown in Fig. 5, could be provided near the base, or a V-2 type of launching platform could be used. This ramp as shown could be rotated through 360° in a horizontal plane and could be tilted or elevated to a maximum of 90° for vertical launching if required. The majority of the launchings would be at about 45°, since 45° is near the optimum climb angle. The ground station would be equipped with radar. Therefore, after an approaching enemy has been detected and tracked for a few minutes, his position would then be known. The launching ramp with the airplane on it would be set accordingly, giving the direction for interception. The sequence of operating the airplane from this point on would be relatively straightforward. The small cylinder would be started and then the large cylinder. This would launch the airplane with an acceleration of about 2*g*. As the fuel is consumed in flight, the acceleration would increase and would be limited to a maximum of 6*g*. Various methods of climb could be employed. The large cylinder could be turned off and on, or it could be operated continuously, depending upon the point at which it is desired to contact the approaching plane. It might be desirable to climb well above the approaching plane and level out directing the warhead toward the approaching airplane. The velocity of the interceptor would be ample for the warheads, and it would only be necessary to supply enough additional propellants to accelerate the warheads sufficiently so that they would leave the interceptor airplane. The margin of performance of the interceptor over the approaching conventional airplane would be great enough so that the interceptor could either attack going in the opposite direction or in the same direction. This is only one of many possible tactical missions; it is not the purpose of this paper to discuss this phase.

In comparing the military effectiveness of a rocket interceptor with more conventional types, we must realize that such an airplane will possess entirely different tactical and logistic characteristics. A current question in operating jet airplanes is "Where are we going to get enough fuel?" The thought of using an airplane with an even more voracious appetite has deterred many from even considering rocket-powered aircraft. This attitude is superficial. The rocket aircraft must not be compared on a time basis but rather on a "per mission" basis. There would be no C.A.P. or search missions for rocket planes. They would be dispatched only when interception is possible. Proper tactical usage might actually permit a considerable reduction in support requirements. A comparison of rocket aircraft with other types must be made on a fundamental basis—i.e., cost to us versus cost to the enemy, including all phases of the operation from factory to final consequences of combat. For example, the comparison on the basis of gross weight would be completely misleading. Initial cost, one of the major elements of the total cost, is most accurately based on empty weight, not gross weight. A comparison of the empty weight of the interceptor previously mentioned with a conventional aircraft serves to illustrate my point.

It should be re-emphasized that many tactical uses of new weapons are conceived by the forces in the field rather than by those responsible for the initial development. Rocket-powered aircraft possesses such unusual characteristics that service tests may reveal uses not foreseeable at the present time.

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FLIGHT SAFETY RESEARCH

by

MAJOR GEN. V. E. BERTRANDIAS*

Excerpts from a Luncheon Address at I.A.S. Nineteenth Annual Meeting

"THE REDUCTION OF AIRCRAFT ACCIDENTS is a matter of great concern to the Secretary of the Air Force, the Air Staff, and all personnel of the Air Force.

"The many ramifications associated with flight safety have presented a serious problem. Reduction of aircraft accidents should be of primary concern to you.

"Accidents are of great magnitude, and their effects are costly in the all-out effort of the Air Force to maintain its skill, proficiency, and a high degree of combat readiness. The added significance and urgency to reach combat readiness is particularly important when gaged by the events in another part of the world. The international situation places more emphasis on aircraft accident prevention.

"Accidents at the present rate are a drain on our combat effectiveness and potential. The preservation of lives and equipment is of cardinal consideration to the U.S. Air Force, and increasing tension in international affairs to include armed conflict has placed a premium on trained crews and equipment. The policy of the Air Force is that all commanders and their staffs and operating personnel at all levels of command are responsible for a continuing and positive consideration of the flying-safety aspects inherent in their assigned functions and responsibilities. They are responsible for an aggressive and positive accident-prevention program to improve continuously the ability of the Air Force to accomplish its required flying mission.

"The Air Force has established in its Inspector General structure an active organization that includes the Directorate of Flight Safety Research and the Directorate of Technical Inspection. The Directorate of Flight Safety Research through The Inspector General is charged with the administration of the regulations and policies that set forth the procedures that have as their primary function the prevention of tragic and costly aircraft accidents.

"The Air Force, through these agencies, attacks the accident-prevention problem from two major areas of effort. These are: (1) research into accidents, accident cause factors, accident-prevention methods and personnel education (where possible the aircraft to determine materiel); and (2) continuing evaluation and correction of maintenance procedures.

"The major area of accident-prevention effort lies within the Directorate of Flight Safety Research. It is the depository for all Air Force aircraft accident reports. It investigates accidents on the scene and reconstructs, where possible, the aircraft to determine material failures when indicated. It analyzes and evaluates accident reports, determines causes, conducts special studies of unsafe practices and conditions leading to aircraft accidents, and publishes and disseminates information and data regarding flying safety.

"A new phase in the operation is to encourage and create a greater awareness of safety problems among design engineers in basic design and to preclude design and functional errors. . .that lead to accidents.

"It is unnecessary to examine Air Force history over a long period to realize that aircraft accidents have always been a major problem. Great strides have been made in both military and civilian aviation, but unnecessary accidents continue to cloud the entire flying picture.

"In analyzing the aircraft accident history of the last war, huge expenditures of our war potential were incurred in noncombat aviation when compared to aviation losses due to enemy action. The aircraft loss to enemy was a small fraction of the total losses. We find the same pattern at this time with our forces in Korea.

* Deputy Inspector General, U.S.A.F.

"In view of the present accelerated Air Force program, every effort should be made to reduce the frequency of these accidents, which can be expected to increase because of the greater complexity and higher performance of new equipment—not to mention that at this time we are inducting Reserve personnel into the service who have for a long period been out of action and must be trained to meet the requirements of handling the new airplane.

"Our potential in noncombat fatalities is alarming. The dollar loss is in the millions, and thousands of lives have been the cost to America since the beginning of World War II. The rate over the past year, although appreciably reduced, has not reduced the cost in dollars because the airplanes of today have tripled in cost.

"An accident-prevention program can be carried out only through the cooperative effort of the producer and the using agency, with the establishment of a flight-safety engineering organization by every manufacturer. The concept of engineering effort as applied to flight safety includes accumulation of data from the many sources in the field and the evaluation of this information, resulting in pertinent recommendations to be accomplished on aircraft in the field, aircraft in production, and aircraft in the design stage.

"To date a considerable portion of the engineering effort of the Directorate of Flight Safety Research has been absorbed in after-the-fact investigations, only one of our many sources of information, instead of covering the entire field as envisioned under our present concept. As the engineering group expands, we will be in a position to take a more active part in preventive work and the integration of results of such work in aircraft at the design stage.

"The proper operational suitability testing of aircraft before being delivered to the using services is another field of activity which has been neglected in the past and in which safety engineering can play a valuable part. Too many airplanes have been produced before the fundamental engineering deficiencies discovered by the flight-test group have been processed and corrective action retrofitted into planes in the field and on the production line.

"In this field, the Flight Safety Research engineering activity has made many contributions, even though it has been functioning for only a relatively short period of time. The lack of proper operational suitability testing is a costly item, inasmuch as the retrofits in a production line, or modification to a production line, are costly to the Government and threaten the combat potential of the aircraft to the Air Force in time of emergency.

"In keeping with our purpose to lead the world in research and development of more advanced equipment, we have in some cases given our combat units equipment neither fully tested nor proved. This condition is being forced on us more at this time because of unsettled world conditions. Aircraft components and accessory units in some cases have not lived up to their designed service life expectancy.

"Safety engineering should be stressed by all members of the aviation industry. To state it more forcefully, it is a fact that airplanes are the product of engineering, and engineering is the solution to the problem, and at times it doesn't appear to be dignified for the engineer to accept any part of the blame.

"The highest percentage of accidents are charged to pilot error. I firmly believe that we have stressed pilot error in an unrealistic term. When no other causes can be determined as a result of an accident, it generally falls in the classification of pilot error.

"This can be further contributed to by the fact that in accident investigations many have not been conducted by properly trained people or engineers capable of placing a proper evaluation on the true cause factor of the accident.

"I question how much effort engineering as a whole has expended on such a simple device as a crash switch that would de-energize electrical systems on contact of the aircraft with the ground, preventing a majority of the fires following crashes. There is much to do in this respect.

"It has been found that many of the most serious accidents result from the malfunction of a system or item of equipment. Even in accidents charged to pilot error, careful study shows that many of them are preceded by a mechanical failure or are the result of mis-use of controls—errors that come out of the emergency procedures and similar items. In many of these cases the basic cause lies in the fact that we are asking too much of the pilot—that the arrangement of the controls in relation to the operations involved is too complicated for a man under the stress of an emergency.

"Airplane design has progressed. Many objectives the airplane designer has met with great effectiveness. They have lost sight of the fact, however, that the human pilot, which the airplane must be made to accommodate, has not progressed in the same manner that the engineers have improved the airplanes. The human pilot weighs just as much as he ever did and takes up just as much precious space in the airplane. Man has not improved the way the airplane has, and he shows little promise of doing so.

"It is true that the human pilot has been studied endlessly and that aviation medicine is producing amazing new facts every day as to his limitations and how to get the most out of his capabilities, but, when all is said and done, he still falls far short of what the airplane designer would like to get from him. Therefore, he must be taken into consideration.

"The human designer must help the human pilot keep pace with his responsibilities in the region of high speed, high altitude, and weather flight over longer distances and for longer periods. This is most vital to the team of the airplane and the man if it is to perform its mission safely and effectively.

"Prevention of accidents can be greatly enhanced through improved design. The effort to achieve this must start with the preliminary design of the new aircraft and be carried through all phases of engineering.

manufacturing, and testing. Every detail of design must be studied for hidden accident potentials, and those procedures failing to meet the standard of safety must be revised. Not only must functional equipment perform its job, but the consequences of a malfunction or of personnel error in operations and maintenance must be anticipated. We have laid stress on performance and weight; at the same time we should consider another feature—safety engineering.

"As a result of serious and diligent study, we find that one big obstacle still rests in the path of engineering. That is the difficulty encountered in order to sell to the agency concerned that, as a result of an airplane accident that involved the death of its crew (and a repeater accident as well), the findings have the merit of having emanated from a comprehensive and undisputable fact that caused the accident. We must have open-mindedness characterized by the unrestrained readiness to accept the truth when it develops, regardless of how surprising it may prove to be.

"Although we do not have a crystal ball, what is the uppermost thought in our mind when such recommendations are made is not particularly stressing safety practices but the proficiency and effectiveness of the airplane to do its mission and coordinate the pilot's ability to perform his mission with the machine.

"Recently, the Directorate of Flight Safety Research negotiated agreements with a number of major aircraft manufacturers to have representatives of their engineering staffs serve with the Directorate of Flight Safety Research on a temporary basis. The plan was designed to work for the benefit of both the Air Force and the people who produce Air Force equipment.

"As a result of this arrangement, Flight Safety learns the problems of the manufacturer, and the manufacturer becomes more familiar with Air Force requirements. This free exchange of essential information is expected to erase many future design and procurement problems and to decrease the economic drain on the nation's resources. The idea was received and accepted by certain manufacturers but has not been entirely accepted by all members of the industry.

"I can say, however, in defense of some of those who have declined to participate, that they have not yet realized the voluminous amount of information that has been accumulated, particularly in the new Directorate of Flight Safety Research, over the past year.

"The first group of engineers have served for a period of 4 months and have returned to their manufacturers. It is hoped that those engineers from the industry who have been working with us will carry back to their engineering groups a story that will be beneficial to them in their basic design planning. I should like to add at this point that the Air Force paid for their employment.

"To add a little further to Flight Safety Research activities, the organization is set up with an engineering division, and through that division it applies approved engineering principles to the design, selection, operation, and maintenance of its airplanes as related to flight safety.

"We are working in direct cooperation with other Air Force agencies and with manufacturers to assure accidents being held to a minimum. We have representatives on the engineering-evaluation boards. These boards are made up of experts who examine airplanes in their initial design stages and mock-up and prototype phases and make safety inspections of the original models. These representatives are interested in the safety of airplanes and their occupants while performing their designed task. They make recommendations for improvements in the airplane, power plant, accessory units, standardization of instruments and controls, lifesaving equipment, and many other items pertaining to the comfort and endurance of the crew on a wartime mission so as to assure the reduction of the accident potential.

"The engineering concept has been developed to a point where we are already realizing encouraging results from our initial efforts. The surface, however, has only been scratched, and we look forward with eager anticipation to new and greater accomplishments. It is through the engineering approach that we hope to encourage industry to be more conscious of the valuable data and statistics compiled throughout our program.

"Closely allied with our engineering effort is our investigation and analysis activity. In many cases of certain types of accidents, it employs assistance of manufacturers and other experts from Flight Safety Research to make on-the-spot investigations of aircraft accidents involving equipment, personnel factors, and other conditions of particular interest. Our investigation teams are made up of pilots experienced in the type of aircraft involved in the accident.

"After causes have been established definitely, recommendations are made immediately through proper Air Force channels and manufacturers to establish immediate corrective action.

"Flight Safety Research is tied in with a vast teletype communication system, and immediately upon the occurrence of any accident this organization is advised in a preliminary form the details of such accident. It is through this communication system that we are in touch with the Air Force world-wide.

"Constantly, we record all 'Unsatisfactory Reports.' In the Air Force an Unsatisfactory Report, or UR, is a report made by the using agency on a faulty piece of equipment or procedure. This report is used as a basis for the initiation of corrective action, either by redesignating or modifying equipment involved or changing the procedure of operations or maintenance. Often a trend of failures that are turned up in Unsatisfactory Reports points the way toward potential accidents.

"Flight Safety Research is further concerned with instrument flying, let-down procedures, and Ground Controlled Approaches. This becomes a more complex problem because of the higher speed and altitudes in which our modern jet aircraft perform. The objective of the Air Force is to have an all-weather air force.

"Another associated activity that ties in closely with engineering, investigation, and analysis is our research into human factors involved in accidents. In Flight Safety Research, medical and psychological experts examine closely all of the human aspects involved in flying aircraft. It was not too long ago that airplanes were comparatively simple machines to which the pilots and crewmen adapted themselves without much regard to comfort or safety.

"Because of the technical developments that have mushroomed during the last war and the years following, the picture has changed considerably. Now we must examine the man in relation to the complex and demanding machine.

"Flight Safety Research has a record and report of every aircraft accident that has occurred since the Air Force suffered its first accident back in 1908. This information is extremely valuable in developing data for our research projects. The benefits of this tremendous wealth of data are available to the designers and can be reflected in the perfection of newly designed aircraft. All of the accident information is recorded on a machine records system so that specific data may be extracted and analyzed with a minimum degree of time and trouble.

"It is recognized that the compilation of records and statistics is meaningless unless information so obtained can be properly evaluated and processed back into our system so that the benefits of such information can be reflected in design changes, changes in standard operation procedures, in some cases changes in the tactical employment, and changes or modifications in aircraft already in the field or about to be delivered.

"Another phase of the Flight Safety Research prevention program. . .is its information and educational activity. This function we consider to be of utmost importance because it is our medium of reaching the commands, pilots, and crewmen who actually fly and service our aircraft. A continuing educational program is a MUST if we are to establish safety in the minds of Air Force personnel which will bring about a reduction in our accident rates. We employ posters, brochures, flying safety magazines, motion pictures, and safety awards to stimulate an aggressive attitude toward accident prevention.

"I do not wish to leave the opinion that the Directorate of Flight Safety Research spells out all the answers or that it is an attempt to govern design or even establish operational procedures. We will always have accidents, and the past year leaves much to be achieved in a preventive program. It is not the Air Force plan or policy to save money at the expense of quality and weapons or equipment. We must have material superior to that which any other nation can put into the hands of its fighting forces. The goal of high-quality weapons in the hands of high-quality men, let me assure you, is the aim of the Air Force.

"I should like to emphasize that national defense is a big business, and we must appreciate that a sound economic structure is our first line of defense and that to jeopardize it with unnecessary losses is as dangerous as any possible enemy. For security reasons I give no figures, but I do stress, however, that accidents are a huge drain on our national resources and a threat to our combat effectiveness.

"Flight Safety Research, during its short time of operation under its new engineering concept, has met with a marked degree of success. This is attested by the fact that the aircraft accident rate in the Air Force has declined steadily since the close of World War II and is still declining. Although the accident rate has reached a new low, the incidence of accidents is still much too high, and the occurrence of fatalities remains as a challenging target that the Air Force and the engineers of industry must seek to eliminate.

"In closing, I wish to invite those engineers of each manufacturer who is interested in this program and who has proper clearance through the Air Force to visit the Directorate of Flight Safety Research at Norton Air Force Base at San Bernardino, Calif."

Plan Now to Attend

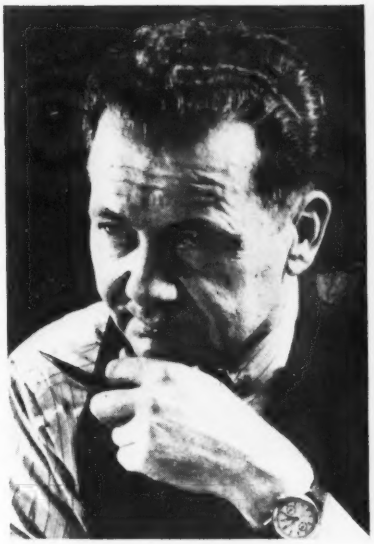
Annual Summer Meeting

Western Headquarters Building

Los Angeles, June 27 - 29

I.A.S.
Nineteenth Annual Meeting

IMPRESSIONS AND COMMENTS*



DR. STEPHEN J. ZAND†
Lord Manufacturing Company

Preamble

BY DEFINITION, PURE SCIENCE, in the past, has always sought to consider the essence of a subject and not extraneous aspects—practical, economic, or military. However, such detachment is impossible in today's world, and the 1951 sessions of the Nineteenth Annual Meeting of the Institute of the Aeronautical Sciences, while devoted as in former years to the investigation of purely scientific aeronautical questions, had a somber pertinency to the pressing problems of our day. Each aeronautical advance highlighted for the individual listener his chances for survival in a troubled world.

For the third time within a generation, some I.A.S. members have been called to active military duty or are serving in some auxiliary capacity, and sons and grandsons of founding members are in uniform. The distant rolling of the drums of war, which in 1945 were to have been stilled forever, rumbled an insistent and ominous accompaniment to lectures and festivities. It is, after all, only a step in thought from Rotating Wing Aircraft to helicopter evacuation of the wounded; from Air Transport to parachute troops; from Electronics in Aviation to detection of unfriendly aircraft and precision bombing; and from Jet and Rocket Power to jet fighters and guided missiles.

Faith and "firmness in the Right as God gives us to see the Right" (and to do it) will determine whether the war drums are beating a Wagnerian ending for all we cherish or a martial rally of the democracies; whether this dark hour is the "twilight of the gods" or a bitter "Valley Forge" wresting victory from defeat.

The Institute is dedicated to aeronautical research and development and to the fellowship among those so engaged. It has achieved stature and stability in its comparatively short life. This was apparent in the planning and execution of a well-balanced, purely scientific program, unmarked by military expediency despite international unrest. The primary interest of each member and friend of the Institute present, civilian or military man, was the advancement of scientific and technical knowledge and development for a peaceful future of air power.

Program Arrangement and General Comments

Though each year's program arrangement must include the "specifics" of aeronautical science, some variation in nomenclature and in treatment of subject matter is welcome. The 1951 program accomplished this to some extent. Last year's Aerodynamics' numerical designation—i.e., *Aerodynamics I, II, III*—gave place to *Aerodynamics, General, Supersonic,* and *Hypersonic.* Of the twelve Aerodynamics papers presented this year, four were on wind-tunnel experimental investigation, a subject not discussed at the 1950 meeting.

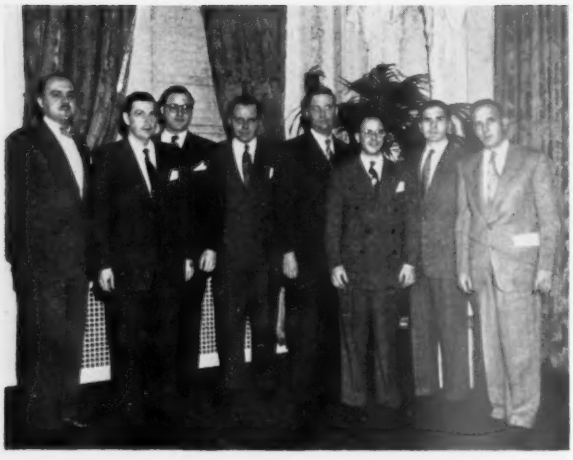
The joint session with the American Meteorological Society exchanged its former prosaic billing, *Meteorology* for the more picturesque *Atmospheric Turbulence,* inadvertently accenting the temper of the times. New York skies cooperated by giving a practical demonstration of superturbulence predicted as "occasional snow flurries." It snowed and sleeted, with high winds all day and part of the night.

Flight Safety, which in 1950 was included in *Air Transport,* qualified for individual recognition this year with its own session on Wednesday afternoon. Rather than pursuing the subject of crashworthiness and fire prevention, conspicuous on the 1950 program, comparative safety statistics and special aspects of air-transport safety were discussed, with Dr. Ross McFarland, author

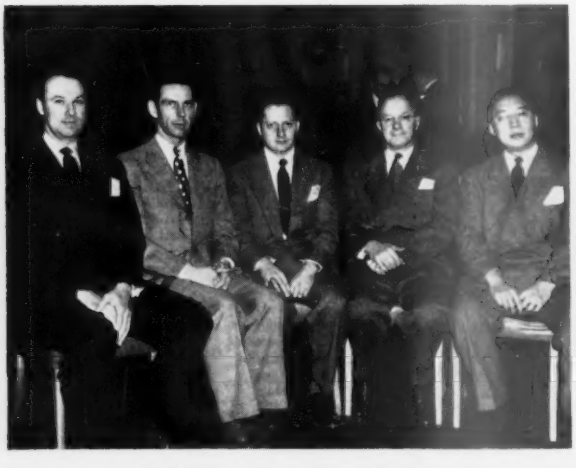
* To my secretary, Miss Alice Bandley, and my Librarian, Mrs. Olive K. Nesbitt, I publicly express a genuine appreciation for their help in transcribing, editing, finding continuity references, and typing these notes.

† Vice-President in Charge of Engineering.

NINETEENTH ANNUAL MEETING



Rotating Wing Aircraft



Flight Propulsion

General Aerodynamics

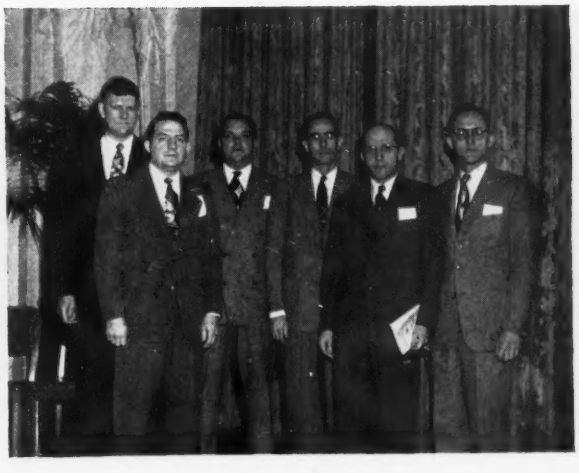
Supersonic Aerodynamics

Hypersonic Aerodynamics

TECHNICAL SESSIONS PANELS

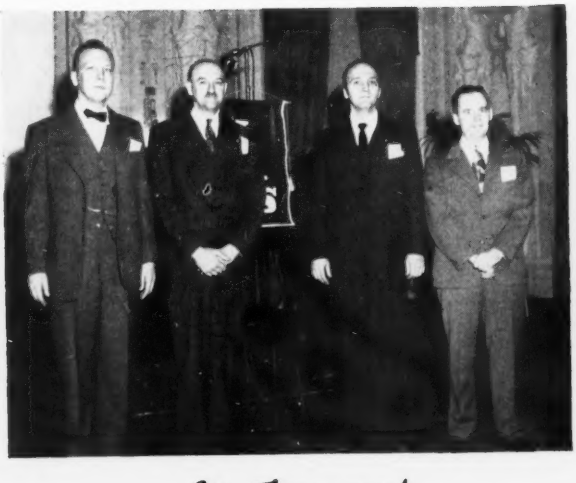
Aeroelasticity

Atmospheric Turbulence



Structures

Flight Safety



Air Transport

of *Human Factors in Air Transport Design*, returning to the I.A.S. rostrum.

The inclusive subject, *Instruments*, was succeeded in this Nineteenth Annual Meeting, by the specific *Electronics in Aviation*, which made its initial bow to Institute audiences at two Thursday sessions held in cooperation with the Institute of Radio Engineers and the Institute of Navigation. Civil and military authorities were well represented on the afternoon panel *All-Weather Flying*, which followed logically the morning session on electronic equipment. That Electronics is an integral part of present and future aeronautical considerations was definitely established. The editors of the AERONAUTICAL ENGINEERING REVIEW and your reporter agreed that the papers and the symposium were of such importance that they should be commented upon by specialists in the electronic field. (The special Electronics issue of the REVIEW next month will cover these sessions.)

Worthy of comment was the recognition of the important role of the Library in the scientific and technical fields. Sponsored by the I.A.S. Libraries, in cooperation with the Special Libraries Association, the "library specialists" convened for the first time as part of the I.A.S. Annual Meeting on Monday afternoon. From time to time, future Annual Meetings of the Institute should accord the Library its place in the sun.

China, France, and Great Britain were represented among the authors of papers delivered at the Institute sessions, thus imparting to this Nineteenth Annual Meeting a slight international flavor. Personnel of the U.S. Army, Navy, and Air Force were present in appreciable number. In fact, the record attendance—S.R.O. at some meetings—was gratifying to the I.A.S. Planning Committee, and the ballrooms of the Hotel Astor hummed with activity.

The usual impressive array of distinguished guest speakers graced the Honors Night Dinner and three luncheons. Presentation of the 1950 Guggenheim Medal to Dr. Hugh L. Dryden and of the I.A.S. Annual Awards and Honors is reported in the March issue of the REVIEW. These preceded the main address by The Honorable James E. Webb, Under Secretary of State.

Renewing old friendships and forming new ones are important parts of every Annual Meeting, and the Nineteenth provided sufficient opportunity for fun and fellowship to balance its sterner side. Your reporter, however, was among the many present at this 1951 meeting who felt keenly the absence of your former commentator, Dr. Alexander Klemin, Founder Member and friend of the Institute, who died last Spring.

More Praise This Year

Whether or not the critical comments made last year by your reporter have produced the desired results no one will know, but the fact remains that this year's papers, with the exception of two, were ably presented and the slides well prepared. The choice of chairmen was a happy one. All of them, specialists in their fields, terminated their respective sessions on time and, in many instances, chose discussers who most likely could amplify portions of the speaker's paper. Your commentator adopted a policy of interviewing the chairmen after the sessions, thus getting into this report the specialist's point of view. He is particularly indebted to Messrs. Lundquist, of N.A.C.A., and Kirchner, of American Airlines, who supplied him with written comments on the various discussions.

Rotating Wing Aircraft Session

Dynamic Frank Piasecki (President, American Helicopter Society), the youngest chairman of the board of an aeronautical company, launched this session with elan. The opening paper, "Dynamic Effects in Rotor Blade Bending," by A. H. Flax, Head, Aerodynamics Research Department, and L. Goland, Associate Research Engineer, Cornell Aeronautical Laboratory, Inc., was read by L. Goland. He presented two methods of calculating rotor blade bending moments for a case where the blade is near resonance with one of the periodic aerodynamic forcing harmonics. One method is a lengthy tabular solution of the differential equation, while the other is by the application of the amplification factor on the static bending moment of the blade. The first is laborious, to say the least; the second is an approximation only; but, fortunately, the two procedures show fairly good agreement. In the discussion, the question was raised whether or not this method is applicable to torsional modes. Since this paper is part of a broad investigation, no definite answer could be given.

Edward F. Katzenberger, Chief Design Engineer, Sikorsky Aircraft Division, United Aircraft Corporation, accomplished his task of presenting "An Investigation of a Rotor-Blade Thermal Ice-Prevention System for the H-5 Helicopter" with great skill. In spots he had to read his paper, but he did it with such proficiency that the audience was hardly cognizant of it. While his paper was specifically referring to the H-5 helicopter, the method of analysis is generally applicable to most rotor hot-air deicing systems. It is a practical application of procedures developed by the N.A.C.A. and A.M.C., and, in general, good correlation between the experimental and analytical techniques was obtained for dry-air conditions. The author did not finish his investigation for wet air, and rotary wing engineers will welcome a sequel dealing with that scope of the program.

The next two papers dealt with the same basic helicopter problem—how to obtain all-weather helicopter operation, which either means the answer to the many questions on how to build a helicopter with greatly increased inherent stability or how to add some means of automatic stabilization to a conventionally designed machine.

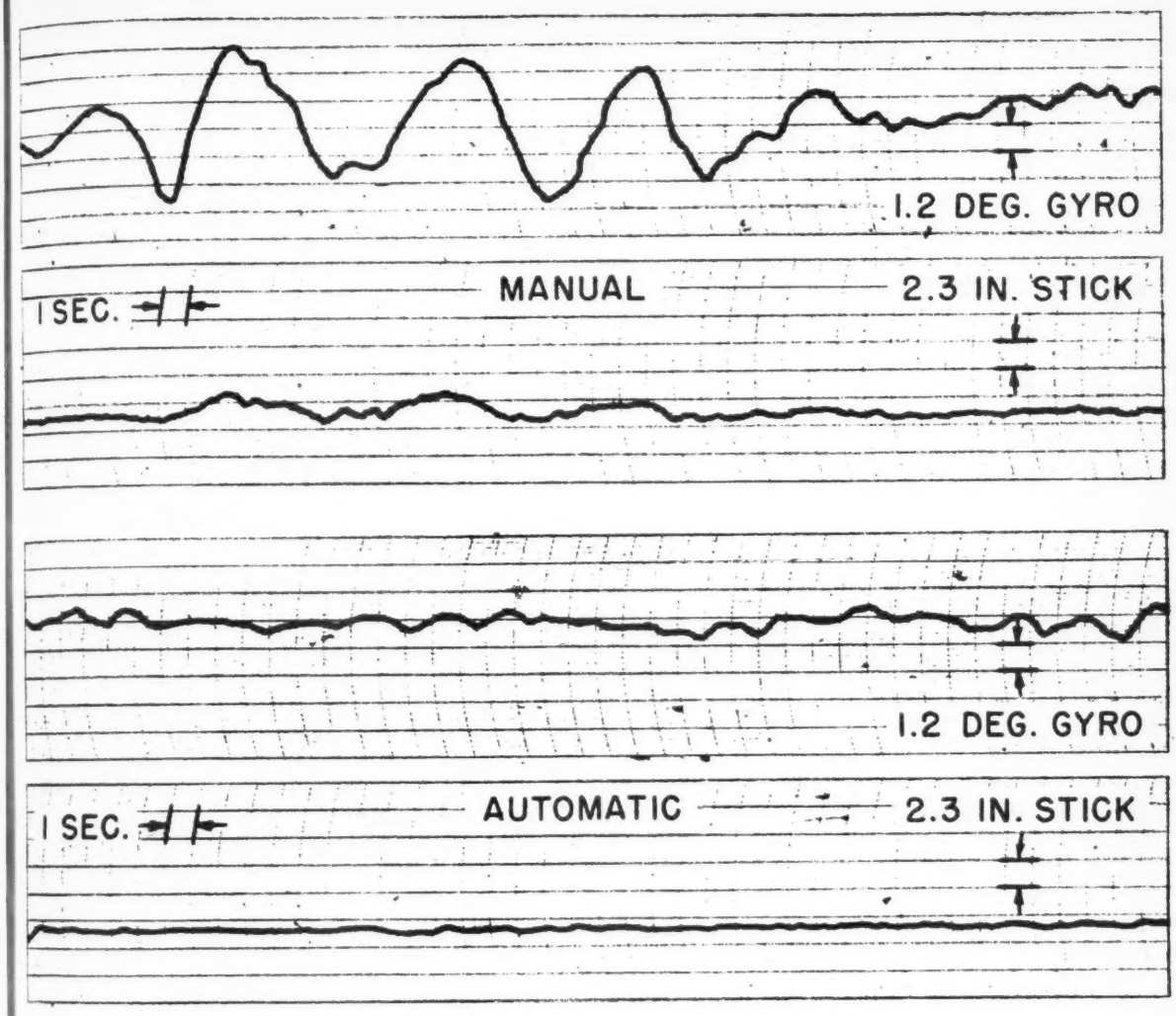


FIG. 1. Comparison of roll characteristics in forward flight.

In the paper, "Desirable Longitudinal Flying Qualities for Helicopters and Means To Achieve Them," Mr. B. F. Gustafson, Aeronautical Research Scientist, Langley Aeronautical Laboratory, N.A.C.A., discussed the first approach, in which he reported that stability with increasing angle of attack can be increased by providing a horizontal tail. Artificial means by the use of special devices can increase damping in pitch, etc., but he points out that the art is not sufficiently advanced to recommend a universal cure-all. While the paper is well organized, your reviewer feels that the treatise could be improved by being more specific. It would also be interesting to know, for example, what happens under hovering conditions.

"A Tested Solution to the Problem of Helicopter Stability and Automatic Control," by E. G. Vanderlip and Donald N. Meyers, Research and Development Department, Piasecki Helicopter Corporation, and P. Halpert, Engineering Department Head for Flight Control, Sperry Gyroscope Company, represented the other point of view. The speaker for the trio was Mr. Meyers, a youthful but mature lecturer. The idea is expressed that any helicopter can be flown "hands-off," provided it is equipped with an A-12 Pilot. Looking at Fig. 8 of the paper (reproduced here as Fig. 1), one is inclined to believe it. It is hard to forego a personal remark. Mr. Halpert, who supplied the autopilot research for the joint paper, is an old friend of your commentator, and it is a pleasure to state that this paper (with due credit to the other contributors) was the highlight of this session. That the paper was well received was exemplified by the fact that the discussion got a little out of control and the chairman had to invoke a time limit to give everybody a chance to participate.

Flight Propulsion Session

Willson H. Hunter, Research Staff, Lewis Flight Propulsion Laboratory, N.A.C.A., was chairman of the Flight Propulsion Session held concurrently with the rotary-wing meeting.

A joint contribution entitled "Practical Aspects of Turbojets in Transport Aircraft," by R. T. Holland

and E. L. Auyer, Aircraft Gas Turbine Divisions, General Electric Company, was presented by the first author. It was a paper of a practical aspect in which the performance factors peculiar to turbine operations were presented. The effects of air-bleeding, nonstandard temperature, altitude, and humidity were ably discussed. Reference to cost of operation and overhauling were made, and anticipated ground requirements were also referred to.

One of the interesting contributions to the rapidly increasing literature on gas turbines was presented next by S. C. Himmel and Richard P. Krebs, Lewis Flight Propulsion Laboratory, N.A.C.A. Mr. Himmel discussed "The Effect of Changes in Altitude on the Controlled Behavior of a Gas-Turbine Engine." In accordance with the tradition of the N.A.C.A., this paper was thoroughly prepared, and the lecturer's resonant voice also contributed to the pleasure of listening to an analysis of data collected on the ground from which response of the engine at any altitude may be computed. It is an excellent proof that electronic analog computers are powerful tools and save a great deal of time. As the speaker pointed out, such performance predictions can be made on turbines because there is only one control instead of the many encountered in reciprocating engines.

Since rockets not only are employed for the propulsion of guided missiles but are used to boost the power of airplanes and may be used on airplanes designed for special purposes, it is fitting that the session included "Application of Rocket Power to Aircraft," by H. R. Moles, Chief Engineer, Reaction Motors, Inc. The author of this paper must have assumed that the aeronautical engineer has little or no knowledge of chemistry or applied physics and spent a great portion of his time describing various propellants and the systems used to employ them. Since the aeronautical literature is explicit on this subject, this part of the paper could have been shortened considerably. When, however, the author started discussing what can be done in a design for a rocket-propelled interceptor, the paper became extremely interesting. He mentioned a hypothetical interceptor of 13,500 lbs. gross weight, of which the fuel load is 8,000 lbs. Such an airplane would have a speed of 2,000 m.p.h., a climb of 50,000 ft. per min., an endurance of 6 min., and a range of 140 miles. Mr. Moles told it so convincingly that the audience thought that for certain military operations such an airplane seemed absolutely practical (see page 24 of this issue for complete paper).

The session was terminated with "A Theory of the Direct and Inverse Problems of Compressible Flow Past Cascade of Arbitrary Airfoils," by Chung-Hua Wu and Curtis A. Brown, Lewis Flight Propulsion Laboratory, N.A.C.A. The paper was read by Chung-Hua Wu. It is believed that compressor designers will welcome this contribution of the N.A.C.A. as a simplification of the involved trial-and-error methods that are so often necessary in the design of blades for such machines. This was a complicated paper to present, since it contains over 30 typewritten pages, 25 figures, and some 40 equations. It is a great credit to the authors that they were able to condense it for presentation and use only the allotted 40 min. Your reviewer cannot improve on the abstract, and what follows is a direct quotation from the summary:

"A new approach to the inverse and direct problems of compressible flow past cascade of arbitrary airfoils is presented. In this approach, the close relation between the shapes of the mean line of the blade and mean stream line in the channel and that between the variations in channel width and specific mass flow on the mean stream line are utilized.

"In the inverse problem, with the inlet and exit angles, a desirable blade thickness distribution, and either a desirable mean line of blade or a certain mean stream line shape chosen, the flow along the mean stream line can be properly determined and easily extended out along the pitch direction by the equations of continuity and motion. The blade boundaries are then determined from the inlet mass flow and best velocity distribution over the blade. For a quick approximate solution of the direct problem, the same process is used with one or more adjustments on the mean stream line to get the right blade shape. The solution obtained in this manner can also be used to give a good starting value for a more accurate solution by either relaxation method for hand computation or matrix method for automatic machine computation. . . ." These methods are also briefly described. "The customary assumption of a linear relation between pressure and specific volume is not required in this approach, and the computations involved are also much simpler and quicker.

"The theory is illustrated with solutions of both inverse and direct problems of compressible flow past typical turbine cascades of highly cambered thick blades. The results are compared with experimental data. The merits of this approach are clearly seen from these examples. The method is directly applicable to two-dimensional flow in axial turbomachines and can be extended to two-dimensional flow in radial- and mixed-flow turbomachines."

General Aerodynamics Session

A. E. Lombard, Jr., Scientific Assistant, Directorate of Research and Development, Hdqs., U.S.A.F., presided at the General Aerodynamics Session, where the first paper, "Simplified Design Comparisons of Axial Compressors," was presented by Frank L. Wattendorf, Deputy Chief Scientific Advisor, Air Engineering Development Division, Hdqs., U.S.A.F. It was a treat to listen to Dr. Wattendorf. One knew that he put great effort into the research and that, whenever mathematical treatment was indicated, it was done in a manner that did not obscure the real physical significance. Dr. Wattendorf gave a brief historical introduction and proceeded to stress the fact that, in order to make the turbojet a more effective propulsion system for supersonic aircraft, it becomes important to increase its

thrust per unit frontal area. One promising method of accomplishing this is by increasing the mass flow through the turbojet per unit frontal area.

The compressor is generally the most critical part of the turbojet with regard to high mass flow. In particular, the influence of hub ratio and axial Mach Number on the stage pressure ratio or temperature rise, based on a limitation of Mach Number for all relative and absolute velocities, is given in this paper for several compressor types designed according to the following principles: (a) free vortex flow, (b) rigid body prerotation, (c) maximum constant rotor work, and (d) unconstant rotor work. The important relationship between maximum temperature rise and mass flow ratio is derived for several of these investigated compressor types. Subsequently, in addition to the Mach Number limitation, the blade-loading limitation is introduced in accordance with presently acceptable values of lift coefficient and solidity. Thus, a general picture evolves of the influence of compressor type on the relationship between temperature rise and mass flow ratio. From the comparison of the free vortex compressor type with the maximum constant rotor work type, Dr. Wattendorf concludes that suitable deviation from the free vortex principle will result in considerable increase of mass flow ratio with reasonable stage temperature rise. This study represents a qualitative method of comparing compressor types and refers to the inlet stage alone. which is usually critical for mass flow.

The next paper, "On the Stability of Two-Dimensional Laminar Jet Flow of Gas," by S. I. Pai, Research Associate, Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, while equally valuable in substance and treatment, was difficult to understand the author or follow the slides, and those wishing to familiarize themselves with the paper will have to study it in its printed form (Preprint No. 310).

R. A. Shaw, Principal Scientific Officer, United Kingdom Ministry of Supply, British Joint Services Mission, Washington, D.C., presented an interesting and novel paper entitled "An Acoustic Theory of Airflow." British scientists always have a poised delivery, and Mr. Shaw, being no exception, is well versed in the art of public speaking. In addition, his thinking reminds one of the great British acoustician, Lord Rayleigh. Mr. Shaw's theory explains some of the disturbance features of real flow on the basis that the flow is in a state of vibratory motion. The theory suggests that disturbance centers in a field of flow may react together, interchanging pulses that travel through the field at the local speed of sound relative to the flow. The time of travel of these pulses determines frequencies that are characteristic of the flow. The geometry of the boundaries, flow pattern, and Mach Number may favor certain frequencies, and the disturbance system may be chosen because it fits these frequencies. The theory has been applied successfully to determine the shedding frequency of the eddies from a circular cylinder and the scale of the cylinder wake. Initial experiments on an airfoil at low subsonic speeds have shown that acoustic vibration of the flow can occur at the predicted frequencies.

The last paper in this session, "A Review of the 8-Meter Modane Wind Tunnel," was presented by Capt. Robert Crawford, U.S.A.F., U.S. Observer at Modane, France. This was a description of the former German 8-m. transonic wind tunnel located on the border of the French-Italian Alps. One of the more interesting features of this tunnel is the availability of 120,000 hp. of hydraulic power coming from a glacier-fed reservoir 2,800 ft. above the level of the tunnel itself. The author also discussed the various techniques that the French engineers used in the initial calibration of the tunnel and compared them with current American methods. This was an excellent review of one of the largest and most elaborate foreign wind-tunnel installations.

Library Meeting

The once fledgling science, Aeronautics, has attained maturity in the last 15 years, and the expanding needs of general aeronautics pose problems of increasing complexity for today's aeronautical engineer. Translated into terms of metals, elastomers, plastics, automatic servo devices, and electronic aids, the cargo plane, bomber, interceptor, helicopter, etc., represent literally hundreds of fields of science and technology.

In this new complexity that transcends boundaries, the Library is an active partner of scientist and engineer, securing, coordinating, abstracting, and making readily available the necessary references. The I.A.S. Libraries are familiar to members as an integral part of the Institute. The Special Libraries Association, cosponsor with the I.A.S. Libraries of Monday's Library Specialists Meeting, may be new to some of the Institute members. As its name indicates, this Association concentrates its interests and services in the specialized fields. With headquarters in New York City, this organization, founded in 1902 and now numbering 5,500 members in the U.S., Canada, and 32 other countries, includes librarians and information experts who serve manufacturing industries, banks, newspapers, research organizations, universities, business, medicine, science, technology, social welfare, and the arts.

Monday's library symposium, under the able direction of Dr. Eugene W. Scott, Executive Secretary, Interdepartmental Committee on Scientific Research and Development, Washington, D.C., discussed "Standardization in Technical Information Services for Government Contractors." A more detailed report on this meeting will be found on page 12.

Structures Session

This account will return to the Aeroelasticity and Supersonic and Hypersonic Aerodynamics sessions after the discussion of Structures. The reasons for this are that your commentator is extremely fond of designing, and the Chairman, E. E. Lundquist, took meticulous notes of the discussion which will contribute

considerably to the explanation of what goes on in the minds of prominent structure engineers. Needless to say, one could not find a better chairman, for Dr. Lundquist has been associated with structures for over 2 decades and is now Chief, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A.

The meeting opened with the paper "An Impulse-Momentum Method for Calculating Landing-Gear Impact Conditions in Unsymmetrical Landings," by R. T. Yntema, Landing Loads Branch, Dynamic Loads Division, Langley Aeronautical Laboratory, N.A.C.A. The author discussed the case of a landing where the airplane touches the ground under unsymmetrical conditions, and he calculated for a large airplane the landing-gear impacts and showed the effects of such factors as sinking speed, wing lift, and side drift on impact severity under unsymmetrical conditions. The importance of landing-gear location and configuration was also shown and compared for two similar airplanes: one equipped with a conventional tricycle arrangement and the other equipped with a quadricycle arrangement. The paper was presented in a professional manner and created considerable interest.

S. Levy, of the National Bureau of Standards in Washington, asked the author if the time between impacts were large enough compared to the period of the first mode in bending in order that this essentially rigid body analysis be applicable. The author responded that he treated only those cases in which the attitude angles of the airplane were fairly large so that the time between successive impacts was sufficiently long.

Mr. Nutter, of the Naval Department Center, Johnstown, Pa., stated that they had found that, where impacts followed each other rapidly, it was important to include the elasticity of the structure and also that such cases resulted in severe conditions. Mr. Yntema, the author, remarked that he did not attempt to treat those cases in which elasticity is important but that he did recognize that elasticity may be an important aspect of the unsymmetrical landing problem in some cases.

John Boshar, of the C.A.A., commented favorably on the paper and said that he would like to see more of that type of work done. He wondered whether or not the effective mass term in the impact of one gear which was obtained from rigid body consideration would be affected by the elasticity of the structure. The author agreed that the severity of the impact is affected by the elasticity of the structure.

Mr. Weiss, of the Goodyear Aircraft Corporation, mentioned that his company had used methods similar to those described by Mr. Yntema in the analysis of their side drift gears and had obtained good results.

One can sum up the paper and discussions by saying that the rigid body action of the airplane in unsymmetrical landing had been well treated, and it would appear of interest to determine the degree of importance of structural elasticity in this problem.

"Allowable Compressive Stresses in Aircraft Structures," by B. E. Gatewood, Associate Professor of Mechanics, U.S.A.F. Institute of Technology, and E. L. Williams, Curtiss-Wright Corporation, was presented next. This paper showed procedures for determining the allowable buckling and maximum compressive stresses in both the elastic and plastic regions for structural materials for which compressive stress-strain curves are known. In particular, curves were shown that are applicable for the aluminum and magnesium alloys. Detailed procedures for obtaining the allowable compressive stresses in both the elastic and plastic regions were indicated for fourteen different cases. The paper is certainly worth keeping for reference since the information can be used directly by the designing engineer.

Dr. Michael Watter, of the Budd Company, remarked that the procedures described might be satisfactory for aluminum alloys but could be considerably in error for highly anisotropic materials such as stainless steel. He also asked if it were not time to give up the concept of the yield point and the proportional limit when speaking of aluminum alloys and whether the term "average load" should not be avoided because it does not give a physical picture of a structure in which the thin sheet elements are highly buckled while the stiffeners continue to take additional load. Dr. Gatewood generally agreed but pointed out that the procedures he described give quick answers to a large group of problems encountered in aircraft design. Chairman Lundquist later commented that the use of the yield point for aircraft structural material is more for the purpose of a concise designation than for a description of the physical properties and that the more recent methods of analysis do take into account the actual nature of the material behavior.

John Meyer, of McDonnell Aircraft Corporation, expressed surprise at the apparent simplicity for the scheme for getting allowable stresses on panels. He also was startled by good agreement with experiment. Dr. Gatewood replied that the good agreement between theory and experiment for one-quarter of the test specimens was due to the fact that these specimens had been used in the development of the empirical theory in the first place. For the remaining specimens the agreement was somewhat worse but still good.

The Chairman, Dr. Lundquist, expressed gratification at the extensive use the authors made of N.A.C.A. reports. He thought they had succeeded well in perceiving the broad objectives and applications underlying the N.A.C.A. work.

The final discusser was George Ray, of Bell Aircraft Corporation, who thought that the procedures devised, which were based on thin-skin construction, could not be extrapolated to thick-skin construction where different types of behavior (e.g., forced crippling) come into the picture. Dr. Gatewood agreed that the application of the methods presented might have to be limited to the types of construction for which the methods were originally developed.

"Some Results of Sweptback Wing Structural Studies," an interesting paper with excellent photographs, was well presented by A. L. Lang, Engineer,

Aero-Elastic and Structural Research, and R. L. Bisplinghoff, Associate Professor of Aeronautical Engineering, Massachusetts Institute of Technology. The authors brought out the fact that static stress and deflection tests have been conducted under laboratory conditions on a 45° sweptback single-cell beam. The results of those experiments were compared with simplified theories and, fortunately, indicated that the agreement, while not perfect, is still completely within acceptable engineering accuracy.

The discussion on this subject was rather lively and was started by Marvin Stern, of Republic Aviation Corporation, who noted that the authors' analyses, based on a four-flange box, could not give any information concerning the chordwise distribution of normal stress and that, therefore, the spar-cap stresses were also questionable. He mentioned some work that he had participated in, in conjunction with the Polytechnic Institute of Brooklyn, in which a more refined picture of the stress distribution was obtained.

S. Levy, of the National Bureau of Standards, joined the discussion to say that the shortcoming mentioned by Mr. Stern could be overcome by adding a substitute stringer to the idealized structure without any basic modification in the method itself. He went on to say that the authors were too modest in describing their contribution to the problem and that the modifications they had made to his method are, in reality, necessary corrections. He remarked further that the method used by the authors to correct their experimental data for unwanted root deformations was a precise and rigorously correct one.

Professor Broglio, of Purdue University, wondered whether the two energy methods the authors applied to the problem gave the same answer. He also wondered whether the authors had found a simple relationship between stress and strain for the nonrectangular panels in the cover of a swept box.

Charles Libove, of the N.A.C.A., commended the authors for investigating a number of different methods of solution to the simplified problem. He remarked that the recent *N.A.C.A. Technical Note No. 2232* the speaker had mentioned corresponded closely to one of the methods described. He questioned whether the idealization of the actual structure into a four-flange box should not depend to some extent on the type of loading.

At this point the meeting was apparently running behind schedule, and at the insistence of the Chairman discussion was curtailed. It was evident that many more ideas could still have been exchanged.

"Buckling from the Standpoint of Dynamics," the last paper, was presented by N. J. Hoff, Head, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn. This paper was certainly masterfully presented, and, while your commentator is a schoolmate of Dr. Hoff, he regrets that he is not one of his pupils. Again, the abstract is so good that it is impossible to improve on it, and it is given here verbatim.

"This paper is a report on an investigation undertaken to clarify details of the process of buckling of columns compressed in testing machines. The behavior of the column was analyzed by means of the dynamic equations of motion, and the results of the calculations were compared with oscillograms obtained in column tests. The major result of the investigation is that the maximum load recorded in a column test need not necessarily be the same as the theoretical instability load. Moreover, the buckling process of inelastic columns differs radically from that of the elastic columns."

One can only add that Dr. Hoff, in addition to the technical aspects of buckling, devoted about half his talk to a historical review of the background of the static strength of columns loaded in both the elastic and inelastic stress ranges. The discussion of this paper was thorough, and Marvin Stern again took the lead and asked the author whether or not he was acquainted with the work of Professor Stoker, of New York University, on the stability of columns loaded above the Euler load. The author replied that he was familiar with this work and that the difference between the two works was that Stoker imposed the loading whereas he imposed the end shortening.

Professor C. C. Chang, of The Johns Hopkins University, congratulated the author on his study and stated that the incorporation of dynamics into column studies was a step in the right direction.

Captain Pritchard, Secretary of The Royal Aeronautical Society, commented that he views with pleasure the increasing emphasis on dynamics in aircraft structural analysis and expressed the thought that a worthy aim of the designer would be to design a "wonderful one hoss shay" of an airplane that, in the event of a crash, would break up piece by piece and then the passengers would step out unhurt.

Dr. John E. Duberg, of the Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A., in commenting on the paper, took exception to the author's statement that the von Kármán reduced modulus analysis gave a complete answer to the problem of the static buckling of inelastic columns. He argued that the classic analysis by which von Kármán obtained the reduced modulus load did not correspond to any real situation and that a more realistic analysis for the load at which column bending starts was that suggested by F. R. Shanley which requires that the load be increased during the initial bending. He further commented that the addition of dynamics to the analysis of inelastic column buckling is a forward step but that as yet there does not seem to be any firm evidence to indicate its significance for aircraft structures.

Dr. Bernard Budiansky, of the N.A.C.A., then commented briefly, indicating that he felt that several of Dr. Hoff's criticisms of the Shanley concept of static buckling were not quite correct. He pointed out that the ratio of compressive to bending increments at the inception of column bending is not indeterminate, as

Professor Hoff implied that it was, but rather is uniquely determinate. Furthermore, the strain reversal that occurred in Professor Hoff's tests before maximum column load was obtained is not inconsistent with the Shanley concept, as was shown by the calculations of Dubert and Wilder. Finally, Dr. Hoff was asked to comment on the conjecture that his results for dynamic plastic buckling would approach the results of Duberg and Wilder as a limit if the rate of loading were permitted to approach zero.

In his reply, Dr. Hoff agreed substantially with Budiansky's comments, pointing out that his criticisms were mainly directed at the work of Shanley rather than that of the N.A.C.A., which he characterizes as correct in every respect. Commenting on the conjecture, Dr. Hoff said that he was not sure but that he felt it entirely possible that the dynamic results might approach slightly lower limits for maximum load than those obtained by purely static analysis.

Because of lack of time, the author did not answer all the discussers' questions individually but closed the discussion with some speculation on what significant findings the research might ultimately reveal.

The success of the Structures Session and the interest of the audience, speakers, and discussers was so great that the chairman asked whether or not some of the people wanted to devote part of the lunch hour to a further exchange of ideas. It was surprising to this reporter and gratifying to the Chairman that no one left the room, and the meeting adjourned at 12:45. Congratulations to all of the participants!

Atmospheric Turbulence Session

This session, conducted in cooperation with the American Meteorological Society, was ably managed by Brig. Gen. Donald N. Yates, U.S.A.F., Assistant Deputy Chief, Staff—Development Hdqs., U.S.A.F. (President, American Meteorological Society). It is this reporter's understanding that the choice of topics was left completely to the discretion of our weather-predicting friends. Last year a similar session was the highlight of all the meetings because one of the speakers was the famous rainmaker, Dr. Langmuir. This year the choice of papers was not too fortunate. The first two could interest the aeronautical engineer. The last three were certainly papers that could not be appreciated by the pilot or the practical weather man.

In particular, "Spectral Theory of Turbulence in Shear Flow," by Chan-Mou Tchen, Physicist, National Bureau of Standards, was extremely difficult to follow, because of the rapid delivery and inadequate microphone technique; also, it required mathematical knowledge far beyond that taught to either aeronautical engineers or to meteorologists.

The best of these papers was the second one, "Frequency Distributions of Velocities in a Turbulent Flow," by F. N. Frenkiel, Applied Physics Laboratory, The Johns Hopkins University, in which the relationship between the frequency distribution of velocities projected on a plane independently of their directions in the plane was measured by a conventional anemometer.

Another paper, "Some Measurement of Vertical Diffusion in the Free Atmosphere," by Lester Machta, U.S. Weather Bureau, was highly informative, since, in general, it is not known that the earth exhales radon, a radioactive gas, both from land and water. The theory assumes that a steady state exists in which the upward diffusion balances the loss due to decay, so that from the vertical distribution of radon one may deduce the coefficient of vertical eddy diffusion. The source of radon is found to be far from ideal for the purposes of the experiment, but this difficulty is, in part, overcome by averaging the observations. The resultant distribution of radon with height up to about 30,000 ft. suggests a coefficient of vertical eddy diffusion which is greater than normally observed near the earth's surface.

The last two papers, "On the Mechanism of Turbulent Momentum, Heat and Water Vapor Transfer in the Atmospheric Surface Layer," by Heinz Lettau, Geophysical Research Directorate, Air Force Cambridge Research Laboratories, and "Averaging Processes and Reynolds Equations in Atmospheric Turbulence," by J. Kampé de Fériet, University of Lille, France, and Visiting Research Professor, University of Maryland, will have to be read by those interested in these matters because your reporter is not qualified to comment upon them. In comparison with other sessions, there was little discussion.

Aeroelasticity Session

This session was under the fine chairmanship of Martin Goland, Chairman, Engineering Mechanics Division, Midwest Research Institute, who is the engineer first to introduce the word "aeroelasticity" in aeronautical parlance.

"Theoretical Investigation of Several Types of Single Degree of Freedom Flutter," by Harry L. Runyan, Herbert J. Cunningham, and Charles E. Watkins, Vibration and Flutter Branch, Dynamic Loads Division, Langley Aeronautical Laboratory, N.A.C.A., was read by Harry Runyan. He concludes that as a result of a series of interesting experiments there is definitely existence of single degree of freedom pitching flutter on an unswept wing both at low and high speeds. He also dealt with specific problems such as: (a) pitching oscillations of an unswept wing, oscillation of an aileron about its hinge axis, and bending oscillation of a swept wing, all in subsonic streams; (b) pitching of an unswept rectangular wing, pitching of a delta or triangular wing, and oscillations of an aileron about its hinge line, all in supersonic streams.

Mr. Ashley, of M.I.T., mentioned that, if one considers additional degrees of freedom, the stability of systems will then increase. He also said that it is difficult to generalize about flutter. W. H. Keen, of the N.A.C.A., questioned the full validity of the calculations, since the authors assume in their mathematical presentation that the problems can be linearized.

This, of course, is a convenient simplification but sometimes may not be in accord with actual physical facts.

"Investigation of Flight Flutter Testing Techniques," by Martin D. Schwartz, Senior Engineer, and Donald L. Wrisley, Engineer, Aero-Elastic and Structures Research, Department of Aeronautical Engineering, Massachusetts Institute of Technology, was also an interesting paper. It was presented by Mr. Schwartz. The authors' main difficulty in collecting their data was the fact that it is difficult to obtain response signals larger than what is commonly known as "hash" signals picked up from random aeronautical and electrical disturbances. A wind-tunnel program was instituted by them to determine how the technique could be improved and applied to a typical model wing. Two excitation methods were selected for development. Sinusoidal responses of suitable magnitude were obtained by installing large rotating unbalances in tip tanks; also, acceptable response amplitudes were provided by the use of externally applied force pulses.

The investigation demonstrated that either technique is practical for in-flight excitation. From the numerical results, the magnitude of excitation required to produce satisfactory amplitudes on current aircraft types was estimated. The relative merits of each method under varying circumstances were discussed in the light of the test results.

Mr. Lombard and Dave Miller discussed servomotor applications, and there were also interesting comments by Lee Wasserman, of Wright Field, who recounted his experiences and was not quite convinced that the investigators' theories and experiments are applicable to transonic speeds. He also mentioned that the mathematics of flutter prediction has advanced considerably in the last few years, but he urged that pressure distribution also be taken into account.

Holt Ashley, of M.I.T., voiced the opinion that the lack of knowledge of pressure distribution killed more people than flutter. The discussion seemed to gather speed, and many other engineers wanted to comment. Unfortunately, time was running short, and the meeting had to go on with the third and last paper, "Determination of Elastic Wing Aerodynamic Characteristics," by William J. Gaugh and Joseph K. Slap, Aerodynamicists, Northrop Aircraft, Inc. Mr. Gaugh, an excellent speaker with a fine sense of humor, provided a mathematical treatment of this problem by taking certain equations in his theories and developing them into series. By taking only two terms, he obtained a correction factor. This value can be used to approximate the aeroelasticity effect on the stability derivatives or hinge moments obtained from any aeroelastic equation. Wind-tunnel data were presented, and they agreed surprisingly well with the calculations. The mathematical treatment is extremely elegant, and the paper is well worth reading.

Mr. Gaugh gave a definition of what an aeroelastic engineer should be. With an unusual sense of humor he defined him as a skier who, going down a steep slope after 1 year's instruction, can simultaneously play a Mendelssohn violin concerto, having learned the violin about 6 months before. Aeroelasticity is, indeed, one of the more challenging branches of aeronautical engineering, since it involves a deep knowledge of all the latest mathematical aids; a fine background in aerodynamics and physics; and, most important of all, common sense.

Supersonic and Hypersonic Aerodynamics

The two sessions, Supersonic and Hypersonic Aerodynamics, can be lumped together, since it is really only a convention to divide this branch of aeronautics into two parts. At the present time, anything up to, and including, Mach Number 5 is supersonic; all speeds above it are classified as hypersonic.

Francis H. Clauser, Chairman, Department of Aeronautics, The Johns Hopkins University, presided at the Supersonic Session and the first paper was "Damping in Pitch of Bodies of Revolution at Supersonic Speeds," by C. B. Smith, Project Engineer, and Beverly J. Beane, Analytical Engineer, Research Department, United Aircraft Corporation. This paper was ably read by the first author, who analyzed the fact that a body of revolution of a supersonic missile, for example, may contribute a damping moment that is greater than that produced by the wings and the stabilizing surfaces.

From the discussion, it appeared to your reviewer that these facts have been known for a considerable length of time and originated with some airship researches conducted by Dr. Munk, who, many years ago, was interested in this craft. The discussion almost went on a tangent, and the old controversy of airship vs. large airplane came to the fore. It was adroitly parried by Dr. Munk, and the meeting proceeded to the second paper, "The Lift Distribution on Low-Aspect-Ratio Wings at Subsonic Speeds," by H. R. Lawrence, Assistant Head, Aerodynamic Research Department, Cornell Aeronautical Laboratory, Inc. This paper, which contains some interesting mathematical speculations, was well presented, although in spots the mathematics obscured the true physical meaning. This can happen when the listeners are composed of two groups: people who are fond of mathematics and others to whom an integral equation means nothing but symbols. During the discussion, questions were asked concerning what would happen if nonlinear effects were taken into consideration, but lack of time prevented the development of these thoughts.

The third paper, "A Limiting Case for Missile Rolling Moments," by Ernest W. Graham, Consultant in Aerodynamics, Santa Monica Plant, Douglas Aircraft Company, Inc., showed excellent preparation, and this reviewer was particularly pleased to note that the Art Department of Douglas had made three-dimensional slides of cruciform wings which were magnificent and enabled the average aeronautical audience to appreciate the fact that Mr. Graham linearized missile rolling moments and studied them for the limiting case in which an infinite number of wings are symmetrically arranged

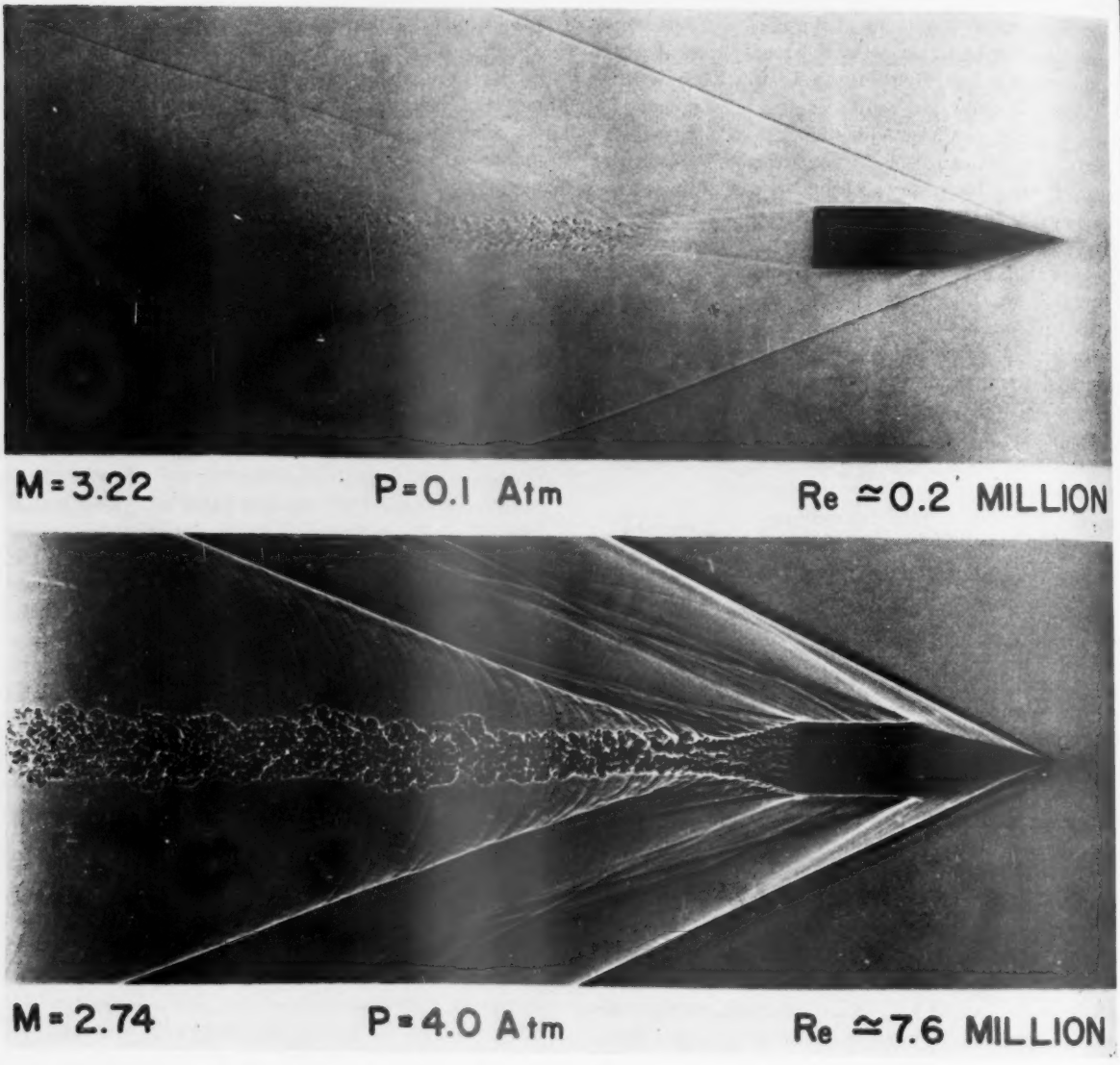


FIG. 2. Wake shapes of projectiles with laminar or turbulent boundary layer.

around a circular cylinder. This case is simple to analyze and is physically interesting for comparison with wing systems that have large interference effects. The analysis is independent of Mach Number and of the longitudinal shape of the wing system. He suggested that, for rolling moments, this limiting case provides a useful comparison with nonplanar wing arrangements, many of which are difficult to analyze.

The last paper, "Interrelationship Between Boundary Layer and Base Pressure," by H. H. Kurzweg, Chief, Aeroballistics Division, U.S. Naval Ordnance Laboratory, White Oak, Md., was, in this reviewer's opinion, the most interesting one, and the presentation was lively. Excellent schlieren photographs illustrated this paper. (One of Mr. Kurzweg's photographs is reproduced herein as Fig. 2.)

The investigations further showed the close connection of the base-pressure problem with other viscous effects—the surface friction and heat transfer. Therefore, it appears that theoretical approaches to calculate base pressure must be made using the characteristic properties of the boundary layer.

Parenthetically, the reviewer wishes to remark that the always excellent N.A.C.A. has serious competition in the staff of the U.S. Naval Ordnance Laboratory. Their papers were extremely well prepared, demonstration material was of high grade, and delivery was of high caliber.

R. J. Vullenz, of Consolidated Vultee Aircraft Corporation, and others discussed the paper, and the chairman concluded the discussion by saying that the difference between the interrelationship referred to above in supersonic flow as compared to the subsonic can be explained by the nonlinearity that probably exists at high Mach Numbers. He stated, however, that this is a conjecture and that further researches will have to be carried out to prove definitely this point.

Dr. C. C. Furnas, Director, Cornell Aeronautical Laboratory, Inc., was chairman of the Hypersonic Session. He ably summarized the whole status of Hypersonic Aerodynamics as it exists today and gave the floor to the first author of a joint paper by Stanford E. Neice and Dorris M. Ehret, Ames Aeronautical Laboratory, N.A.C.A., who discussed the fact that the hypersonic similarity law, as developed by Tsien and extended by Hayes, for bodies of revolution at zero angle of attack can be tested by comparing pressure distributions obtained using the method of characteristics. The results indicate that, in spite of the assumption made in its development, the hypersonic similarity law is valid for relatively wide ranges of Mach Number and fineness ratio.

Another splendid contribution to the knowledge of hypersonics, "Summary of Recent Experimental Investigations in the N.O.L. Hyperballistics Wind Tunnel," was given by Peter P. Wegener, Chief, Hyperballistics Subdivision III, U.S. Naval Ordnance Laboratory. He gave a description of the 12- by 12-cm. wind tunnel, which can operate up to 60 atmospheres and 500°C. The author brought out the fact that, at very high Mach Numbers, liquefaction of air can take place, seriously affecting the true results. He showed methods of avoiding such phenomena and also gave preliminary criteria of operating conditions to achieve uniform flow suitable for test purposes. Remarks on the aerodynamic characteristics of simple bodies, boundary layers, diffuser efficiencies, and testing problems in a Mach range from 5 to 10 concluded the paper.

"Exploratory Wind-Tunnel Investigation of Wings and Bodies at $M = 6.9$," by Charles H. McLellan, Head, 11-Inch Hypersonic Tunnel Section, Langley Aeronautical Laboratory, N.A.C.A., was the next paper. Mr. McLellan appeared somewhat nervous at the beginning of his presentation (perhaps because he saw Dr. von Kármán in the first row), but, once over his stage fright, his delivery was smooth. He talked about results of an exploratory investigation of wings and bodies at a Mach Number of 6.9 in the Langley 11-in. hypersonic tunnel. Force and pressure-distribution data were obtained on a square and a triangular planform wing having 5 per cent thick diamond sections, on a cone cylinder body of revolution, and on a flat-bottomed or half-cone cylinder body.

The last paper, "Recent Investigation of Temperature Recovery and Heat Transmission on Cones and Cylinders in Axial Flow in the N.O.L. Aeroballistics Wind Tunnel," by Gerhard R. Eber, Chief of Thermodynamics Subdivision, U.S. Naval Ordnance Laboratory, dealt with the temperature recovery factors and heat coefficients of cones and cylinder bodies up to, and including, Mach Number 5. He was well prepared, and the treatise could have produced a serious discussion. Unfortunately, the meeting had to be adjourned.

This reviewer feels that the session was extremely valuable to the general I.A.S. membership in that it applied to the related science of external ballistics. Since guided missiles are a borderline case between ordnance and aeronautics, it is most important that the Institute gave the aeronautical engineer a chance to increase his knowledge on this modern subject.

Air Transport Session

The Air Transport Session's chief navigator was Otto E. Kirchner, Director, Operational Engineering, American Airlines, Inc., veteran air-line executive.

"Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Ft." was presented by H. T. Harrison, Jr., Manager of Weather Services, United Air Lines, Inc. He introduced the audience to many of the concepts of jet streams in the atmospheric layers in the region of the tropopause. These jet streams are layers of high-velocity air currents, restricted in depth and width and associated with turbulence at its edges. The paper reminds one of the difficulties of forecasting to the tolerances used at present. If the limits are made broader, then the reserve fuel requirements will have to be increased. This is especially critical in jet operation (for complete paper, see page 52 of this issue).

Joseph Lyman and George B. Litchford, Aircraft Radio Research Department, Sperry Gyroscope Company, presented "Distance Measuring Equipment (D.M.E.) for the Terminal Area." This paper brought out the necessity for some clarification in the use of abbreviated terms for describing air traffic equipment and procedures. The use by C.A.A. and the Sperry Company of Distance Measuring Equipment (D.M.E.) in the future is sure to lead to confusion and misunderstanding, since the two schemes are dissimilar.

Some members feared that the anticipated rate of landings per hour was highly optimistic. To obtain safely high utilization, the authors made it clear that their work was not in any way in conflict with present C.A.A. plans. It will supplement it when such control for terminal areas is needed. For "zero-zero" landings there is no system yet available which is completely satisfactory.

R. W. Rummel, Chief Engineer, Transcontinental and Western Air, Inc., gave a historical review of the development of pressurized cabins, stressing the fact that T.W.A. has considerable experience in this art. Pressurization is a costly undertaking both from a capital outlay point of view and cost of operation and maintenance. The overhauling of supercharges is expensive. Failure rates are high, and improvement of detail design is desirable. Other air-line representatives disagreed that passengers had to be convinced of the advantages of pressurization. According to Mr. Rummel's observations, when superchargers are inoperative, the travelers complain bitterly. Some discussers suggest that in the new designs the cabin altitude should be lowered.

The last paper, "Fatigue Problems in Transport Aircraft," was presented by W. T. Shuler, Chief, Structural Section, Airframe and Equipment Branch, C.A.A. He pointed out that air-frame fatigue failures constitute a

serious nuisance but usually do not offer a threat to airworthiness. The discussion showed that the science of metallurgy has so far not produced irrefutable criteria enabling the structural engineer to establish realistic fatigue limits. Data are being accumulated, and it is expected that a solution will be found in the not-too-distant future.

Flight Safety Session

Whenever a paper deals with human problems, one can rest assured that the meeting hall will be filled to capacity, and that is exactly what happened at the meeting on Flight Safety under the direction of Jerome Lederer, Director of The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University. The chairman is a veteran safety engineer, who has spent most of his professional life in the analysis and improvement of safety records in aeronautics.

C. Christenson discussed "Some Special Aspects of Air Transport Safety." One could not find a better qualified speaker than Mr. Christenson, who is now Flight Safety Engineer for United Air Lines, Inc., and has been with them for many years. The author is a Captain of the Mainliners and has to his credit the fantastic number of 15,000 pilot-hours, in which he covered roughly 3,000,000 miles—a most enviable record. The main theme of his talk, which was presented with great poise and dignity, was that accidents can be eliminated in scheduled air transports. This fact can be accomplished if airplanes are designed not for top performance but for utmost safety. He pointed out that it is entirely wrong to design an airplane, release it after some flight testing to the air lines, and let the air line modify it as they see fit. He mentioned that the public does not want to fly in an experimental airplane. Among other interesting features, he mentioned the fact that in many instances the designing engineers evolve procedures to be followed by the pilots which are only "crutches for poor design." Similarly, the demand for accuracy and dispatch under emergency procedures should not be used to cover up inadequate design.

In summary, Mr. Christenson emphatically pleaded: "Design more, invent less." Dr. Edward Warner competently summarized this paper by stating that designers should anticipate "what will happen if ----." He suggested that they take advantage of the accumulated statistical experience, being aware that a change of one single parameter in a complex situation may disproportionately affect the resulting sum. Mr. Christenson then added that airplanes should not be designed for the superpilot but should be built in such a way that the marginal pilot can still fly them safely. He explained that, because of the unpredictable human factor, the superpilot may temporarily become marginal. If it were not for the fact that there were two additional interesting papers scheduled, your reviewer and the rest of the audience would have questioned the author and discussed his paper to the end of the session.

R. Modley, Research Consultant, Aircraft Industries Association, talked on "Comparative Significance of Transport Safety Statistics." This paper was startling to those who think in terms of standard statistics or who believe that there is one death per 100,000,000 passenger-miles. The major shortcoming of this standard lies in the fact that it omits from consideration disabling injuries. If one takes into account the disabling injuries produced by railroads, buses, and passenger cars, the transport airplane looks much safer than it first appeared to be. Dr. Munk did not agree with this thesis and philosophized on accidents and statistics, closing his argument by saying that, since there are no pedestrians in the air, one cannot apply statistics to the nonexistent. Most of the listeners, however, felt that a further study of Mr. Modley's ideas might give a more realistic picture and certainly could be used to counteract some of the tasteless advertising that one occasionally sees.

The last paper, "Human Engineering for Air Safety," was presented by an old friend of the Institute and an expert in his field, Dr. Ross A. McFarland, Associate Professor of Industrial Hygiene, Harvard School of Public Health. He said that the safety record in scheduled air transport flying suggests that current research should be devoted to the subtleties of the problem, such as the prevention of near accidents and the anticipation of new problems. The paper analyzed the conflicting interests of the aircraft designer, the air-line operator, and the air crews in establishing wider margins of safety. He emphasized design problems relating to high-speed high-altitude flying in current and future transport models.

L'Envoi

The trip to the Special Devices Center, U.S. Navy, at Sands Point, being a classified visit, cannot be described here. All your reporter can say is that it coincided with his sending in his income tax for 1950, and, as a result of the demonstrations and lectures, the payment did not hurt at all.

What 1951 will bring nobody knows. Will there be a meeting in 1952? Your guess is as good as your commentator's.

Pardon the appending of a personal note; one thing I know definitely. I will not be your reporter next year. I like to write. I considered it a great privilege to comment without editorial directives on your efforts, but I have written myself out. If you say so, and if I am still alive, I will comment on our Silver Anniversary Meeting 6 years from now. I hope I have been of service to you. My sincere compliments to the chairmen, authors, discussers, members, officers, and the staff of the I.A.S.

MILITARY RESEARCH AND DEVELOPMENT

by

PHILIP B. TAYLOR*

Excerpts from a Luncheon Address at I.A.S. Nineteenth Annual Meeting

Introduction

"The size and scope of the military research and development program in this country today is rather startling. Rough estimates show that this program engages the services of about two-thirds of the nation's scientists and engineers and accounts for nearly two-thirds of the entire national expenditure for research and development. These percentages are expected to go even higher.

"A program of this magnitude, involving about 11,000 separate projects, warrants the most careful guidance and thorough coordination at all levels to attain the greatest possible effectiveness, and the Research and Development Board was established to do this job. . . .

"Secretary of the Navy Forrestal and Secretary of War Patterson chartered the Joint Research and Development Board in June, 1946. Because of his long experience in the field, Dr. Vannevar Bush agreed to undertake the establishment of the new Board. In the year and a half preceding unification, the Joint Research and Development Board demonstrated that it filled a definite need, and it was subsequently given statutory authority by Congress in the so-called 'Unification Act' of 1947. The 'Joint' was dropped from its name at that time, and it has continued in operation as the Research and Development Board. Organizationally, it is located at a staff level to the Secretary of Defense, coequal with the Joint Chiefs of Staff, the Munitions Board, and the War Council."

Organization and Membership

"Dr. Karl T. Compton succeeded Dr. Bush as Chairman of the Board, and the present Chairman is William Webster. Except for the Chairman, the seven-man Board is made up entirely of part-time members from the three departments. These are a civilian assistant secretary or under secretary and one military officer from the Army, the Navy, and the Air Force. The administrative and staff work of the Board is carried on by the Secretariat, headed by Dr. Eric A. Walker as Executive Secretary.

"The R.D.B. operates through 15 technical committees, representing a breakdown of the military research and development program into the principal fields of effort. The committees at the present time are the following: Aeronautics, Atomic Energy, Biological Warfare, Chemical Warfare, Electronics, Equipment and Materials, Fuels and Lubricants, Geophysics and Geography, Guided Missiles, Human Resources, Medical Sciences, Navigation, Ordnance, Scientific and Synthetic Analysis, and Technical Information. The chairman and members of these committees serve on a part-time basis and comprise civilians from industrial and academic life and senior military officers from military departments."

Committee on Aeronautics

". . .Our duties are all in the category of advising the Board itself and stem directly from the Board's responsibilities. These can be broadly summarized as follows: to ensure that there are no gaps in our program, as well as no unwarranted duplication of effort; to ensure that there is proper relative emphasis on all

* Chairman, Committee on Aeronautics, Research and Development Board.

phases of our program; and to estimate for the operations people the strategic capabilities that they can expect in service from the weapons we are developing.

"To accomplish these duties, our yearly work calendar has four major tasks. These are the preparation of a Program Guidance Report and the preparation of a Technical Estimates Report, the Budget Review, and the Facilities Review. In addition, of course, we catch a good many fire drills and one-shot items, which result from day-to-day changes in plans and requirements. . . ."

Program Guidance

". . .Our annual cycle of operations can be considered to start with the preparation of a Program Guidance Report. The purpose of this report is to provide those concerned with research and development activities affecting the mission of the Department of Defense with the best available guidance for their research and development programs. The document is to assist the agencies of the Department of Defense in the preparation of their research and development budgets and is the point of departure for Research and Development Board reviews of the research and development programs. Proceeding along the lines I just outlined, each of our panels is asked to review its areas and to make recommendations as to which programs require additional emphasis, which programs should be continued at the present rate, and which programs should be decelerated. As a basis for these recommendations, the Joint Chiefs of Staff have previously furnished us with information regarding the relative strategic importance that they attach to the various fields of warfare. In addition to this strategic importance rating assigned by the Joint Chiefs of Staff, panel considerations must be influenced by the adequacy of currently available weapons and by the promise of substantial dividends from further research and development efforts. Evaluation of all of these factors helps in determining the relative urgency of all competing programs. These factors are obviously nebulous and in some cases are entirely inadequate. One problem that continually faces us, for example, is the relative emphasis that should be given to long-term basic research at the expense of more immediate development work. While it is mandatory at this time that improved weapons now being developed be readied for service use at the earliest possible date, we cannot afford to neglect our basic and applied research or our development program will eventually become sterile. Yet, without knowing what future developments may stem from the long-term research programs, it is difficult to assign a relative importance rating to the basic research items.

"Reports from each of the panels are forwarded to our Committee and integrated into a Committee report. Since each panel is most keenly aware of the need for additional support in its own area, the integration of panel recommendations into a Committee report that will fit expected budgets has, in the past, been a somewhat painful process. However, the present international situation has resulted in increased funds for research and development to such an extent that dollars may not now be paramount. Instead, we may soon find ourselves most severely limited by a scarcity of technical personnel or of suitable facilities for research and development.

"Our Committee Program Guidance Report is coordinated with other interested committees and is forwarded to the Research and Development Board. Here another integration of committee reports takes place, and the detailed recommendations are summarized in broader terms.

"The formal Program Guidance Report as finally published by the Board is the result of so many integrations, coordinations, and summations that it has lost much of the detail needed for actual implementation at the working level. We find, however, that an interesting phenomenon has occurred. The preparation of this report at every level (that is, in the Panels, in the Committees, and in the Board) has been accomplished by the military members who are intimately concerned with these projects in their daily work and by the injection of civilian thinking of the most competent civilian members that we can obtain. The working levels in the Army, Navy, and Air Force have therefore had the benefit of round-table discussions and examinations and of the advice of civilian experts who could not be hired on a full-time basis. The Research and Development Board has therefore accomplished much of its objective before its formal report is even published."

Technical Estimates

"A second important task on our Calendar is the annual preparation of Technical Estimates. By its Directive, the Research and Development Board is required to inform the Joint Chiefs of Staff concerning the estimated technical performance and estimated time schedules of weapons systems proposed for, or in processes of, development. The purpose of the Technical Estimates is to inform the Joint Chiefs of Staff of what militarily significant improvements in weapons, equipments, and techniques can be expected to result from current and contemplated research and development programs. This report is also being increasingly used by service schools in their studies of the impact of new developments on military operations.

"In preparing this report we again start out at the panel level but with a slightly different slant. The Joint Chiefs of Staff are concerned with the overall performance of the end weapon—that is, the airplane, including its engines, armament, and equipment. We try to present our estimates of future performance, therefore, in terms of the complete airplane rather than in terms of the individual components. This not only requires that our panels work closely with one another but also necessitates the formation of special *ad hoc*

groups composed of representatives from the Committees on Ordnance, Electronics, and Guided Missiles, as well as Aeronautics. Since most of the new aircraft prototypes now being developed will not see service use for several years, the job of making short-range estimates is not too difficult. As we get further into the future, however, we must extrapolate past experience and keep our fingers crossed."

Budget Reviews

"A third duty of the Committee is the annual review of the military research and development budget. The proposed budget prepared by the Departments normally reaches us in the Spring and reflects in terms of dollar figures the broader recommendations previously contained in our Program Guidance Report. In the recent past, when economy was the watchword, these Budget Reviews were important. Dollars were scarce, and every effort was needed to make sure that the available nourishment was equitably distributed to all members of the family. Although we could not progress as fast as desirable, we had to maintain a balance of effort in all parts of the aeronautics field to obtain the most effective end weapon, since the end weapon is only as good as its weakest component. As I said before, however, dollars are now becoming more available and may not be our most severe limitation. Current thinking is that the Budget Review may be superseded by a Technical Review, and we may be able to devote more of our time to the technical soundness of programs and to the coordination of technical personnel and facilities to carry them out. I believe that we will still have to talk in terms of dollars, however, since they are the most readily usable yardstick of effort."

Facilities Review

"A fourth task with which our Committee is concerned is the review of proposals for new research and development facilities. As you know, a sizable part of our research and development program is carried out in Government facilities. Large air stations such as Muroc and Patuxent are needed for testing new aircraft developed by all military contractors; laboratories such as Wright Field and the Naval Air Material Center at Philadelphia are used to evaluate the contractors' products; and large engine test facilities, such as the ones being built at Trenton and at the Arnold Engineering Development Center, which could not be financed by any private contractor, must be constructed by the Government and made available to industry.

"Funds for building these new facilities and for improving existing facilities are separately appropriated in the annual Public Works budget. Our job is to try to match the technical capabilities and the readiness date of these proposed facilities with the planned programs that will require them, with the availability of technical personnel to operate them, and with the programming of funds to support them. Here again, the work starts at the Panel level. Our Facilities Panel carries the ball, and, by means of numerous field trips for familiarization and by consultation with other panels having cognizance of the planned work load, they must produce a single priority list integrating the construction proposals of the three services. The priority list approved by our Committee is later integrated with those of other Committees into a single R.D.B. priority list of research and development facility proposals. This list is then forwarded to the Munitions Board for inclusion in the Public Works budget."

Conclusion

". . .It is difficult to evaluate the jobs that the Aeronautics Committee and the Research and Development Board are doing. I can say, however, that we have. . .as competent and devoted a group as can be found anywhere, many of them serving without compensation. The Military Departments have been supporting the effort with cooperation and understanding, and a better job of research and development and of effective use of funds has been done than if this organized effort were not made.

"As to the future, I personally hope the Aeronautics Committee and the Research and Development Board can develop a program heavily weighted toward the following policy objectives:

"(1) Assign a definite proportion of research and development effort—say 10 per cent—to basic research, and protect this against the inroads of urgent short-range development items.

"(2) Continue the development of items of proved effectiveness, until a successor takes over, in actual combat under all conditions of warfare. We have recently, I believe, gone too far in our acceptance of atomic bombs, pushbutton war, and jet engines as a solution for all types of combat.

"(3) Hold within reasonable limits the resources dedicated to enormously complicated and expensive research equipment to avoid unwarranted diversion of effort from the objective to the equipment.

"(4) Encourage competitive development of solutions to difficult problems, but constantly coordinate results and limit the number of types prior to production but retain some competition even in production items.

"(5) Last and most important, develop within the Government a basis for sustained support of the Research and Development program, and eliminate present year-to-year budget fluctuations."

Some Meteorological Problems Indicated for Jet Transport Operation at 40,000 Ft.

HENRY T. HARRISON*

United Air Lines, Inc.

Introduction

Current plans by aircraft operators and tentative production schedules by the manufacturers suggest that we are facing an evolutionary step in scheduled air transport in the near future which will involve some major changes in our operating philosophy. From the present-day cruising levels at 20,000 ft. and lower with long-range flights, it now appears that we may bypass the 30,000-ft. level and go directly to the 40,000-ft. cruising level when the long-range jet transports are introduced in regular service. It is appropriate, therefore, that we consider what is known about the climate at that altitude and appraise it in terms of its probable effect upon our flight planning and operating procedures. In analyzing weather patterns at 40,000 ft., this paper will ignore factors that may still be present during the take-off-climb and descent-landing stages. Those factors will present an entirely different type of problem and one that merits a separate investigation beyond the limits of this study.

Among the weather factors that figure most prominently in affecting the operation of long-range flights today, it appears reasonable that we should remove thunderstorms and icing from the list of elements giving trouble at the cruising level. While it is known from the National Thunderstorm Project Work[1] that thunderstorm cells often build up vertically beyond 40,000 and even 50,000 ft., observational evidence is also fairly strong that these are isolated peaks and that only infrequently should we encounter solid walls of cumulo-nimbus cloud at those heights. It is a fair assumption, then, that jet transports will be capable of avoiding thunderstorms at cruising level merely by making brief diversions from normal flight track. With regard to icing in supercooled clouds at cruising level, the chances of this occurring would seem to be as slight as the probability of meeting a solid front of thunderstorm clouds at 40,000 ft. Warm frontal cirro-stratus cloud sheets will certainly reach up to that altitude at times, but these clouds should hold only a minimum of supercooled water droplets, if any at all. Recent tests by Schaefer[2] and others have demonstrated what appears to be a spontaneous crystallization of water drops at temperatures close to $-39°$, regardless of whether or not ice nuclei are present in the atmosphere. As we shall see shortly when the temperature pattern is studied, it will be only on rare occasions that temperatures as high as $-39°$ will be encountered across continental United States at 40,000 ft.

Presented at the Air Transport Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Manager of Weather Services.

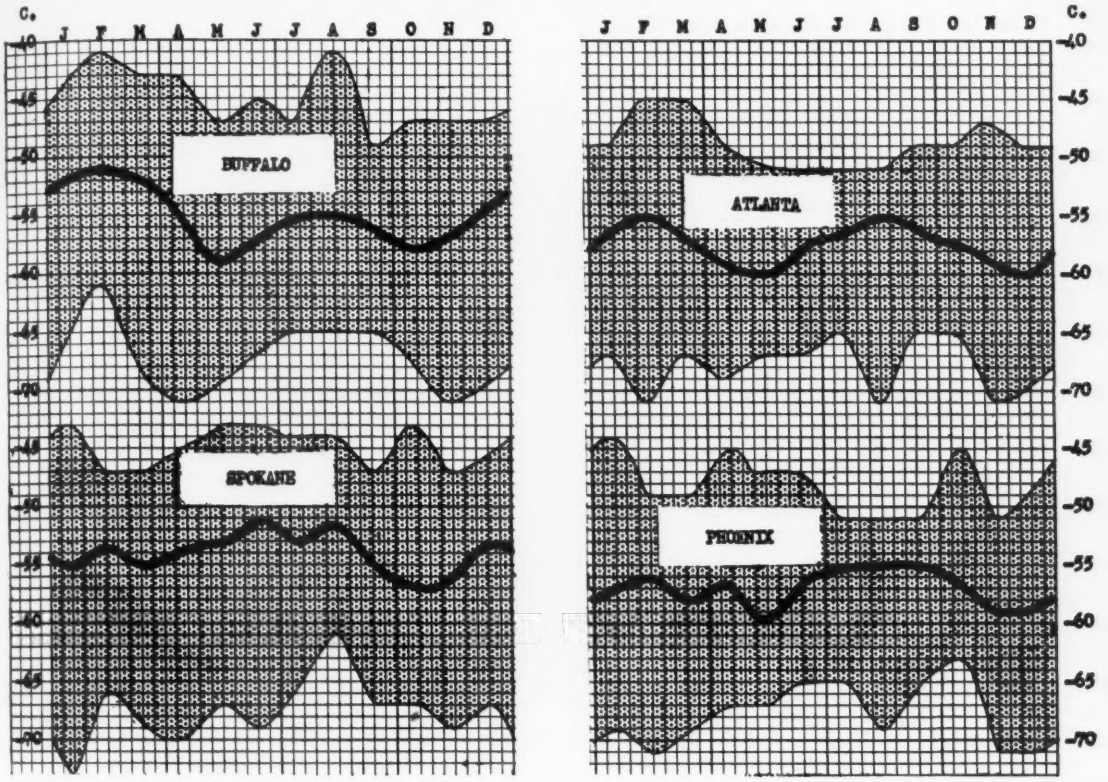


FIG. 1. Median temperature and extreme temperature over U.S. at 13 km. From U.S. Weather Bureau data, 1939–1944.

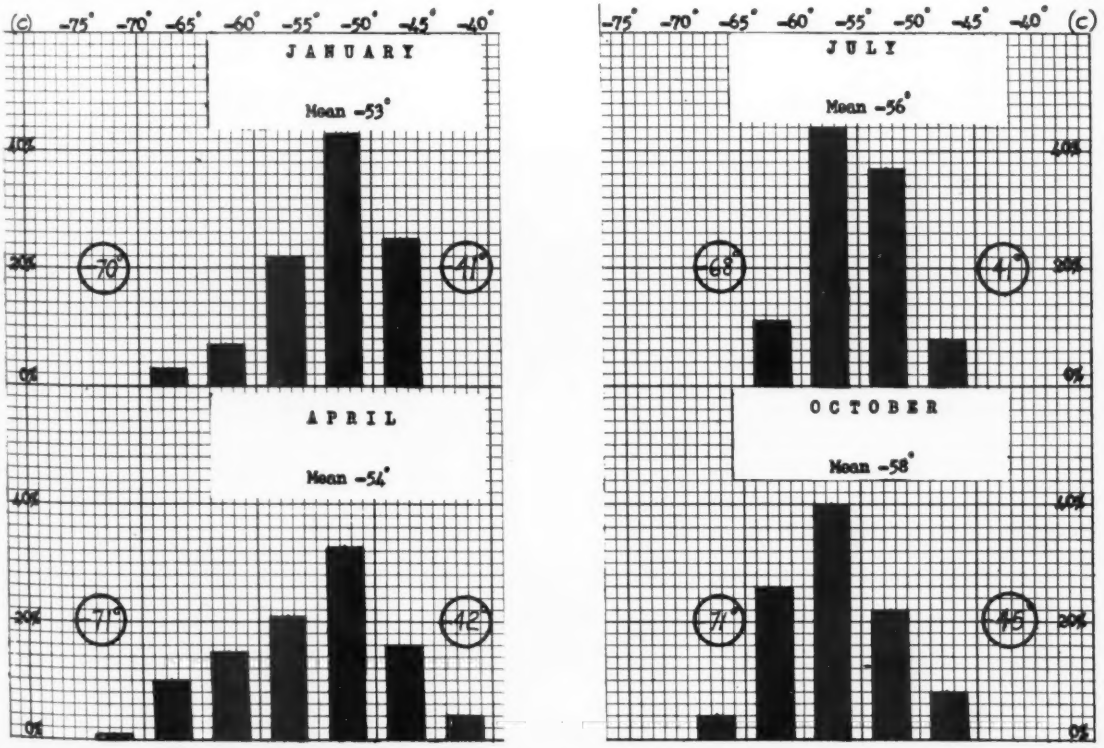


FIG. 2. Frequency distribution of temperature increments at Buffalo at 13 km. From U.S. Weather Bureau data, 1939–1944.

If we agree that thunderstorms and icing may be eliminated from our considerations, we are left with three weather factors that should demand our consideration—namely, temperature, wind, and turbulence.

Temperature

Temperature will be of interest from the standpoint of power-plant performance and possibly from the angle of unusual expansion and contraction to which the air frame will be subjected within a matter of minutes. The *de Havilland Gazette*,[3] in appraising the effects of weather upon the operation of the Comet, has estimated that an error of 5°C. in a temperature forecast for cruising level will be roughly equivalent to an error of 10 m.p.h. in the wind forecast and that either will result in an error of approximately $3^1/_2$ min. in the estimated off-to-on time for a 2,000-mile flight. Experience in this country tends to confirm the assumption that the weather forecaster is capable of staying within the first tolerance, but there is considerable doubt about his ability on wind-speed limits, a point that will be discussed again under the wind section. If we look at Fig. 1, it can be seen that the range of temperature in any single month at 40,000 ft. can amount to as much as 30°C. Day-by-day changes will not be so severe as at lower levels, however, because the horizontal thermal gradient notably flattens out considerably as we go up from 20,000 to 40,000 ft. A cursory study of a file of 200 millibar charts indicates that in only rare instances will a single flight of 1,500 to 2,000 miles experience a gradient in excess of 10° to 15°C. at cruising level. For schedule-planning purposes, it can be seen from Fig. 2 that the mean frequency distribution of temperature is such that summer flights will find temperature within a 10°C. range 80 per cent of the time, but in the spring the curve is much flatter over a range of 25°C., which means that power plants will give varying performances from day to day. It would thus appear that temperature will offer a minor problem in maintaining schedule regularity but that weather forecasting from the synoptic charts should be capable of staying within a tolerance of ∓5°C. error in forecasting temperature for operational flight-planning purposes.

For overall exposure to ambient temperature range, it appears that jets must expect to run the gamut from +115° to −100°F., or from +46° to −73°C. It is even conceivable that individual flights on warm summer days will experience a fall in temperature of 200°F. during the 15 min. or less which will be required to reach cruising level after take-off or, conversely, the same order of rise in temperature during descent. Engineers concede that this is a factor to be kept in mind but are inclined to feel that violent changes of this nature are not likely to prove serious.

The temperature lapse rate in the upper levels carries another interesting implication for jet flights by revealing the height and characteristics of the tropopause on a mean basis for schedule-planning purposes and on a day-by-day basis for flight planning. As we shall see when we look at the matter of clear air turbulence in a later section, there is increasing evidence now that the tropopause is going to be significant to flying because of its frequent association with mildly turbulent air. Looking at Figs. 3 and 4, it is apparent that summertime operations at 40,000 ft. will be conducted well below the stratosphere but that during the colder months of the year jet transports will have to penetrate the tropopause almost daily

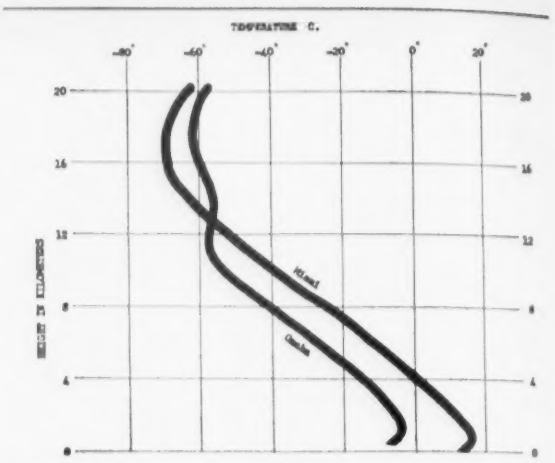
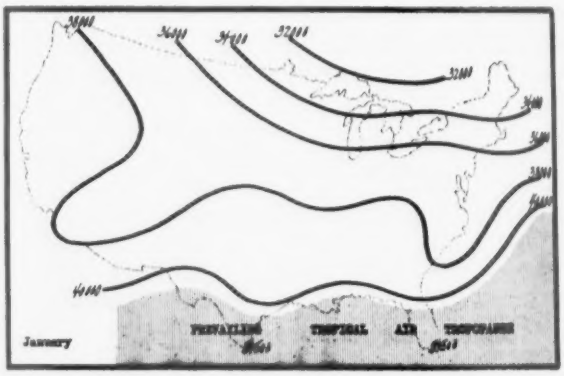


Fig. 3. Mean temperature lapse rate curves for January. From U.S. Weather Bureau Report "Temperature Frequencies in the Upper Air" by Benjamin Ratner.



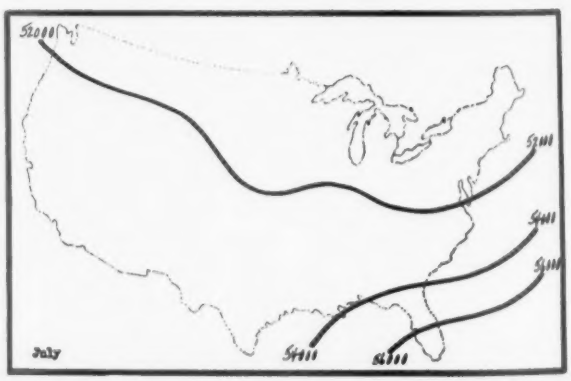


Fig. 4. Average height of tropopause. Computed from U.S. Weather Bureau data, 1939–1944.

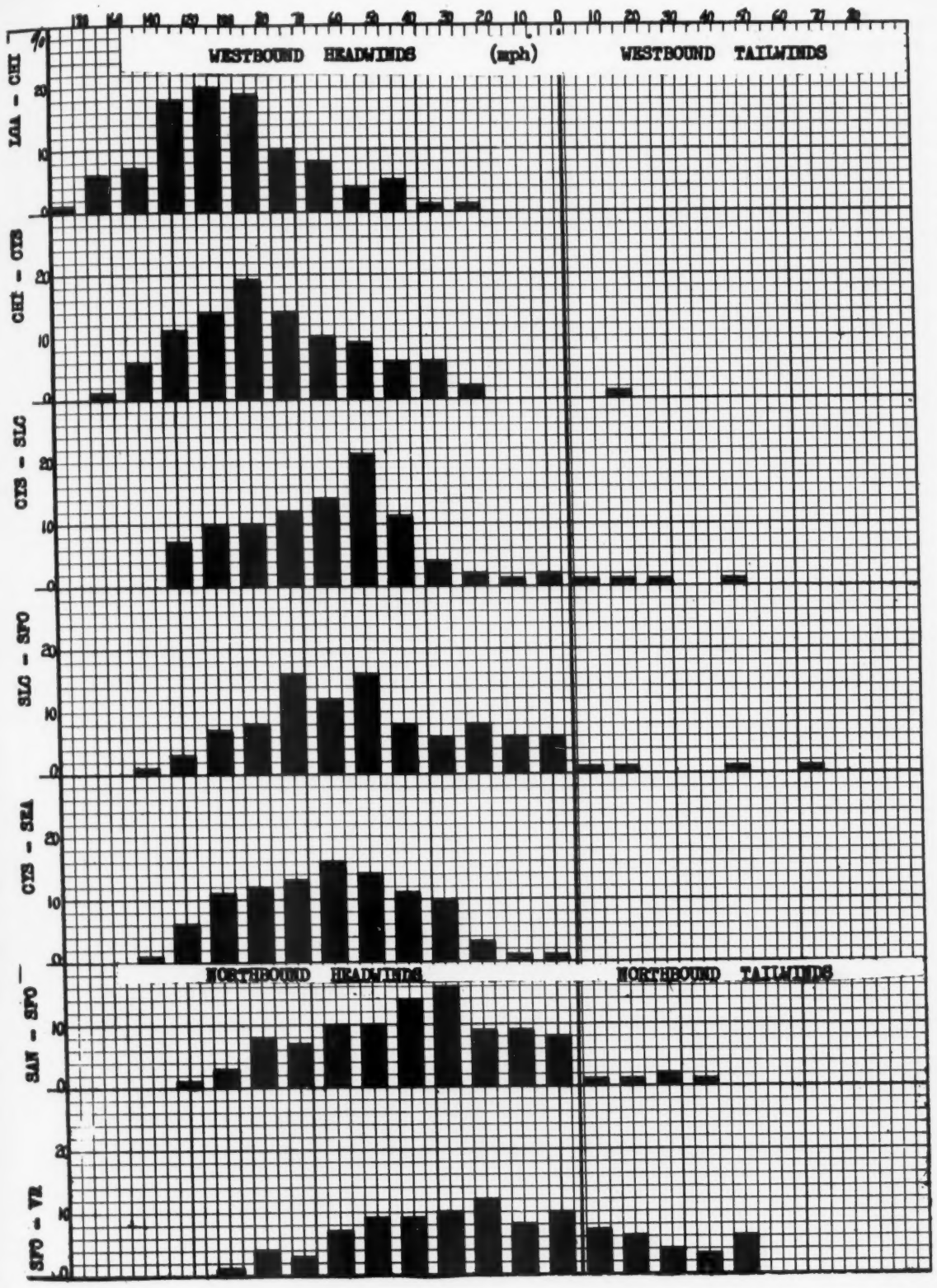


FIG. 5. Sample frequency distribution of wind components at 30,000 ft. in winter. From "Frequency Distribution of Wind Components at 30,000 Feet Over United Air Lines System," April, 1947.

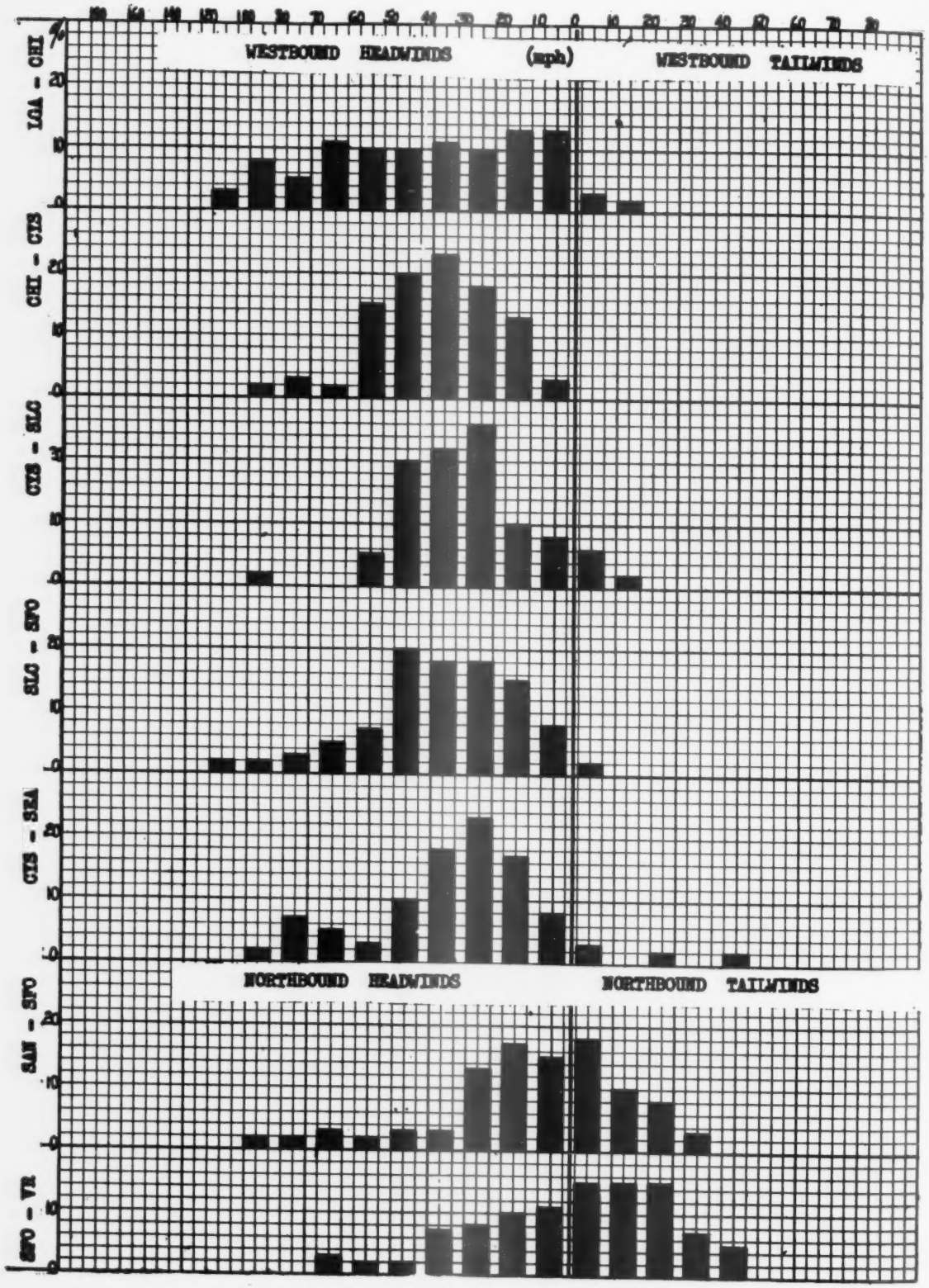


FIG. 6. Sample frequency distribution of wind components at 30,000 ft. in summer.

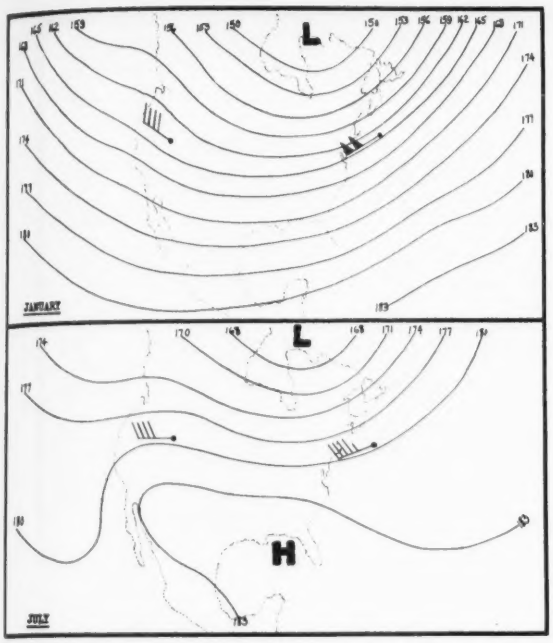


FIG. 7. Average isobars at 13 km. From U.S. Weather Bureau "Normal Weather Maps Northern Hemisphere Upper Level."

when climbing to, or descending from, the cruising level. The mean height of the tropopause across mid United States will be found at 37,000 ft. in January, with cold Polar air troughs and LOWS forcing this level down to 20,000 ft. or less for brief periods.

WIND

Winds at cruising level will have an important bearing on long-range schedule-planning and on day-by-day flight-planning problems. Even though the new aircraft will cruise at speeds of 500 m.p.h. or more in still air, wind components of 100 m.p.h. or more will be found fairly frequently on most continental routes in midwinter. If our yardstick of schedule reliability is to be set at 80 per cent, it can be seen from Fig. 5 that flights between New York and Chicago in January must allow for westbound headwinds of about 130 m.p.h. and assume eastbound tailwinds of about 70 m.p.h. This means, in effect, that our 500 m.p.h. aircraft will be scheduled to make good a ground speed of 570 m.p.h. eastbound but only 370 m.p.h. westbound over this route in winter. In the summer (Fig. 6), the spread will not be so great. Westbounds would be fixed to a headwind of about 65 m.p.h. and eastbounds to a tailwind of about 10 m.p.h. It should be noted that the New York–Chicago Airway wind pattern is representative only for routes in the northeastern portion of the country where high wind speeds aloft are notorious. Jet-stream winds can occur anywhere in the country, but the frequency is less and the routine day-by-day wind speeds aloft are lower over the western and southern portions of the country. These wind figures are only tentative because they are based on a sampling of 30,000-ft. winds for 1 year, with monthly abnormalities being smoothed out by computing each monthly frequency distribution on the basis of a 90-day period centering on that month. Average isobars are available for the 13-km. level, however, and it is apparent that the pattern at 40,000 ft. is similar to that at 30,000 ft., as shown by Fig. 7. If we scale off the theoretical "mean" wind from the averaged isobars on the 10-km. charts, it is evident that the two gradients are nearly identical but with slightly higher wind speeds indicated at the upper level. It is further evident, from a study of the normal pressure maps published by the U.S. Weather Bureau,[4] that the prevailing westerlies usually reach their maximum speed close to the 40,000-ft. level and taper off steadily from that altitude up to at least 60,000 ft.

For daily flight-planning purposes, it is apparent that meteorologists will have to develop new forecasting techniques and that the U.S. Weather Bureau will need a closer network of reliable RAWIN stations in order to meet air-line operational requirements for jet flights. With engineers implying that fuel reserves for jet transports will have to be closely computed because of economic reasons, it is probable that forecast errors of 20 per cent in mean wind component will be of a critical nature. Where a 10-m.p.h. tolerance is satisfactory when dealing with winds of 50 m.p.h. for conventional aircraft, an error of 30 m.p.h. on a jet-stream condition of 150 m.p.h. winds at 40,000 ft. will be another matter. It is doubtful that present-day synoptic methods can stay within that tolerance when dealing with the meanderings of jet streams or

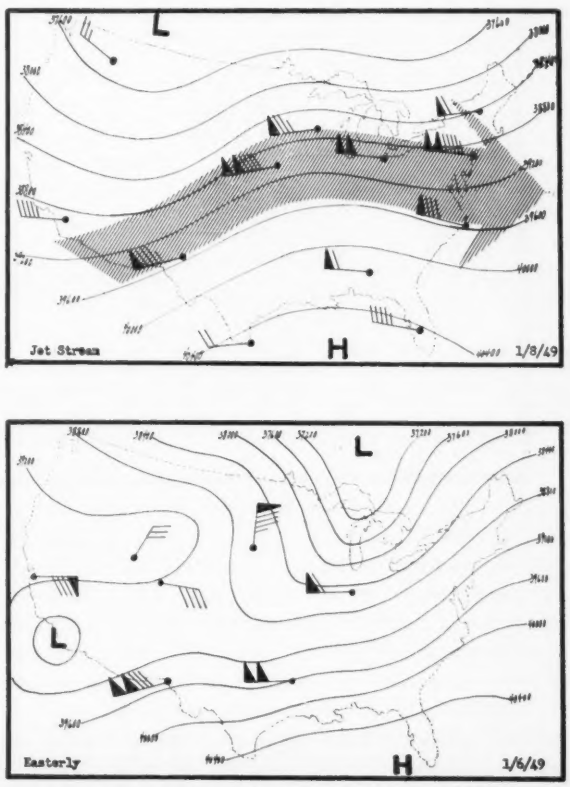


FIG. 8. Examples of abnormal windflow at 40,000 ft.

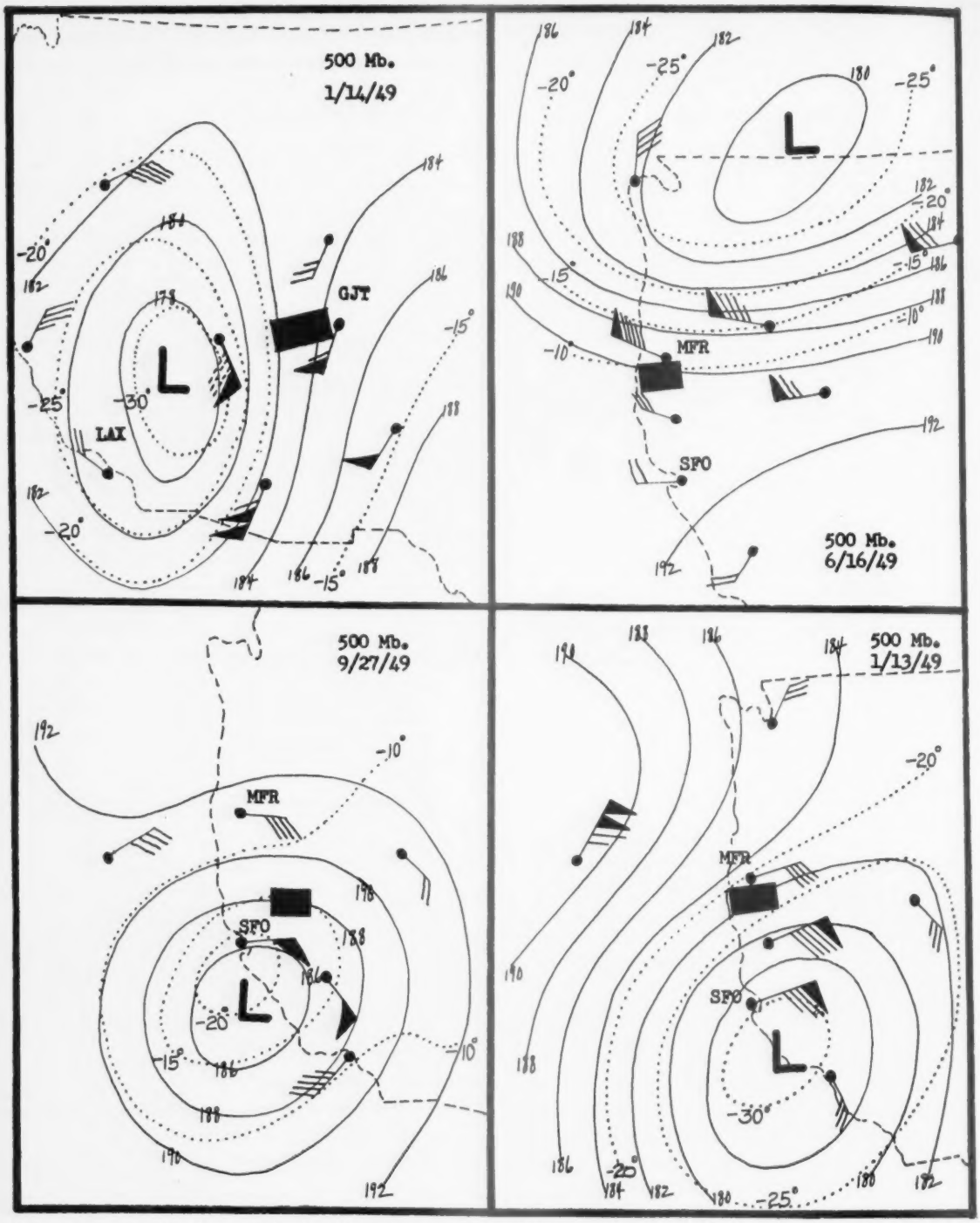


FIG. 9. Cases of cold LOWS associated with high-level clear air turbulence. From *United Air Lines Meteorology Circular No. 34.*

with the occasional sudden 180° reversal of winds attending the development of closed LOWS at upper levels. Examples of these map types are shown in several of the figures. With better observational data, however, and with experience increasing our knowledge of the characteristics of jet streams and cold LOWS, there is promise that weather forecasters will be capable of meeting operational requirements under all but exceptional developments of windflow aloft.

TURBULENCE

The phenomenon of clear air turbulence at high levels has been receiving increasing recognition in the past several years as a result of our operational experience with pressurized equipment flying at the 20,000-ft. level and, more recently, as a result of a research project conducted in Europe over a 2-year period by British European Airways.[5]

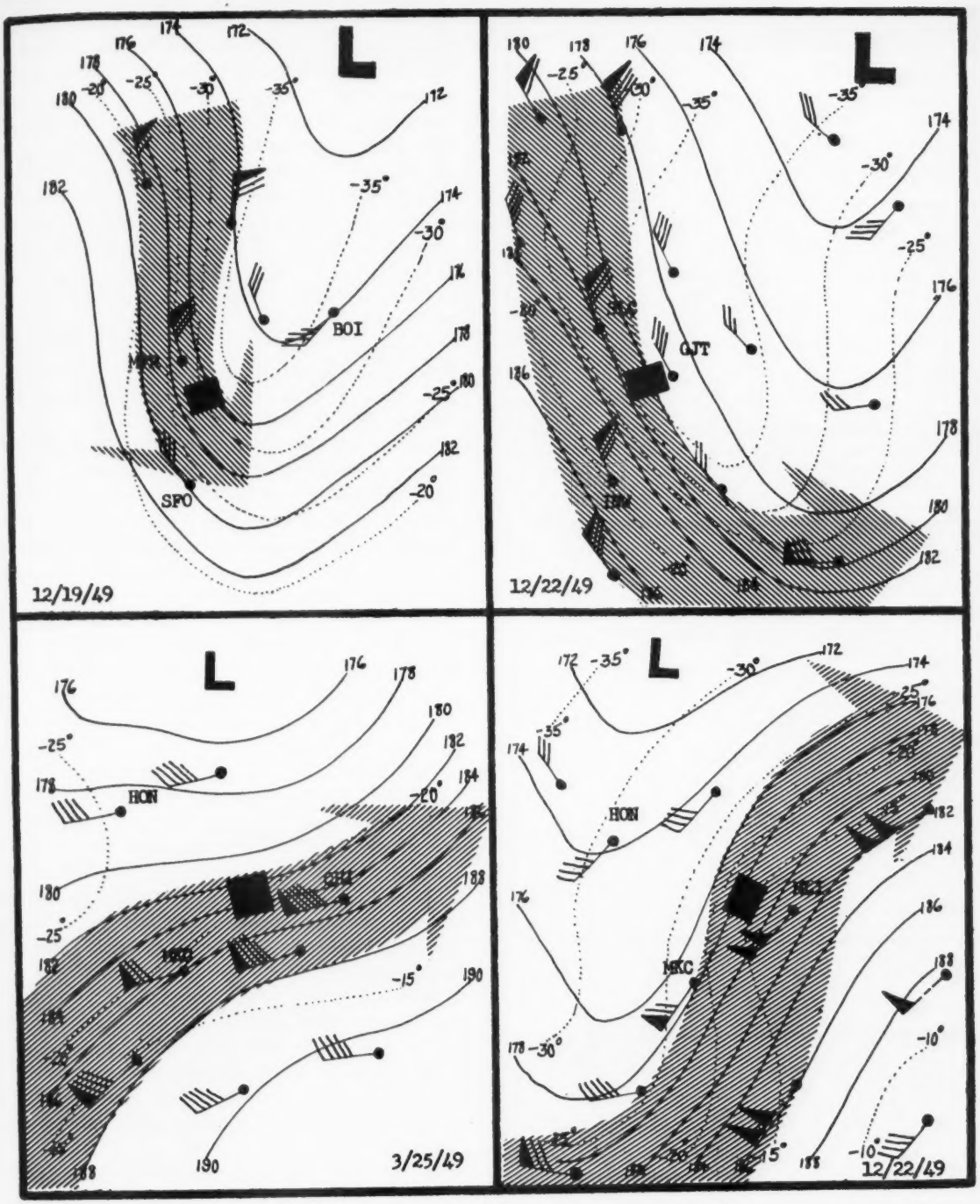


FIG. 10. Cases of moderate to severe clear air turbulence above 15,000 ft. with jet streams. Cases of jet streams associated with high-level clear air turbulence. From *United Air Lines Meteorology Circular No. 34.*

The British European Airways project brought out some interesting characteristics of clear air turbulence which will be pertinent to our future flight-planning problems. Their flight crews found turbulence always occurring completely without warning, being characterized by a short sharp hammering repercussion on the aircraft somewhat similar to the sensation of driving a car over railroad ties at high speed. Turbulence was generally found in isolated patches that were typically about 3,000 ft. in thickness and between 50 and 100 miles across. In 92,300 miles of flying sawtooth patterns, 20 areas of appreciable turbulence were encountered which ranged in intensity from appreciable choppiness, which would discommode a passenger, up to a maximum equivalent vertical gust velocity of 26 ft. per sec. E.A.S. Even when converted to U.S. standards, this figure is well within the range of turbulence described by the National Thunderstorm Project pilots as "heavy."[1] Extrapolating the observed data and allowing for the fact that the

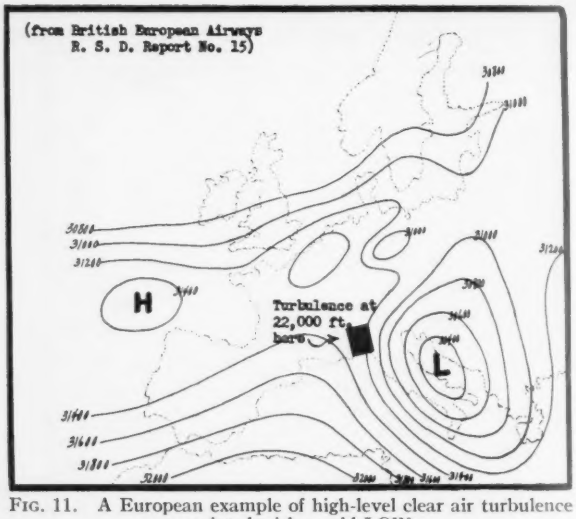


FIG. 11. A European example of high-level clear air turbulence associated with a cold LOW.

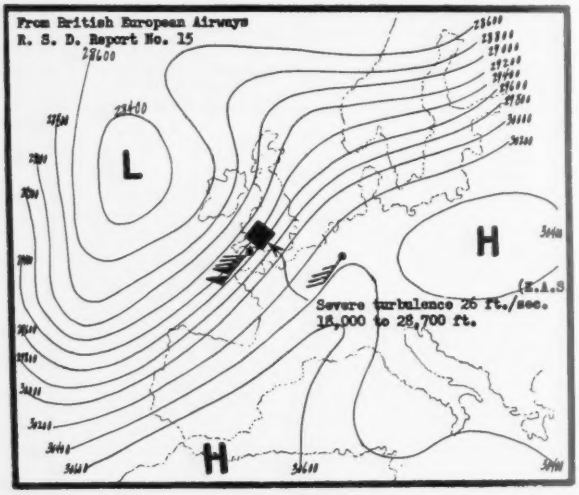


FIG. 12. A European example of high-level clear air turbulence associated with a jet stream.

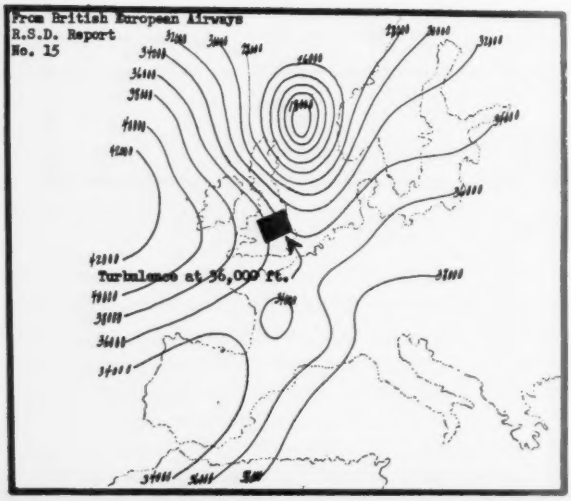


FIG. 13. Contour lines of a steeply sloping tropopause associated with a high-level clear air turbulence.

research planes went out intentionally to seek turbulence, the B.E.A. report estimates that a fleet of 20 high-speed aircraft might reasonably expect to encounter a 36 ft. per sec. E.A.S. gust once in 2 weeks and a 50 ft. per sec. E.A.S. gust once in 4 years in flying over Europe between 20,000 and 40,000 ft. These figures are not so severe when converted to U.S. standards, but there seems to be little doubt that turbulence is going to pose a very real operating problem. A preliminary United Air Lines study in 1949[6] brought to light a total of eight cases of clear air turbulence in continental United States over an approximate period of 1 year which were described by pilots as "moderate" or "severe." No formal program of reporting turbulence was in effect, however, so we must consider that these eight cases represent only those known to have occurred.

The United Air Lines study in 1949 found that all cases of moderate to severe turbulence in the clear above 15,000 ft. had been encountered under one of two unique weather map types as shown on the 500 millibar chart—one, along or near the periphery of a cold LOW with closed isobars aloft, and the second along or near the edge of a jet stream where strong horizontal gradients of wind speed and temperature were observed (see Figs. 9 and 10). In flying over 90,000 miles with two Mosquito aircraft over Europe at levels between 15,000 and 37,000 ft., the British project reached about the same conclusion with reference to clear air turbulence in that region. The B.E.A. report did add two other factors that were believed to be significant in determining areas where turbulence would be found. (1) Their conclusion was that a marked wind gradient in the vertical, associated with a strong temperature gradient in the horizontal, is perhaps the most likely cause and is in conformance with previous theoretical studies of atmospheric turbulence. (2) They found that half of their high level cases of turbulence were encountered within 2,000 ft. of the tropopause. Again, the suggestion was that the basic cause might well be wind gradient in the vertical, a condition that is found under some types of steeply sloping tropopause as shown in Fig. 11 or a condition that might be found with the discontinuous type of tropopause which is occasionally observed.

To the forecaster and the flight planner, this is obviously only a start toward a solution of the problem. While we appear to be able to isolate those cases under which turbulence *might* be found, it is evident that turbulence will actually be experienced only in certain limited regions under certain types of jet streams, cold LOWS, and tropopauses. Even though we learn more about the mechanics of this type of turbulence, it appears likely that the synoptic forecaster is going to experience considerable difficulty in issuing more than a negative type of forecast, because the B.E.A. samplings revealed turbulence as occurring in relatively small isolated patches. When we consider the spacing of the standard RAOB and RAWIN networks, it is

obvious that patches of that size could well occur outside the field of observed data and, further, that efforts to fill in the gaps by interpolation might give misleading results. Perhaps our best hope at this time is that the forecaster will develop empirical methods or be able to inject indirect aerology into forecasting methods which will give reasonably accurate results until such time as we have acquired sufficient direct experience with the phenomenon to permit analyzing it in greater detail.

Summary

The weather forecasting and climatological problems at 40,000 ft. for jet transport operations thus appear to shape up as follows:

(*1*) *Temperature.*—Current synoptic methods should prove entirely satisfactory in preparing accurate forecasts of temperature for flight-planning purposes. For long-range planning purposes, present knowledge of temperature patterns at 40,000 ft. is adequate.

(*2*) *Wind.*—Observational data and current synoptic methods must be expanded and refined if we are to have accurate forecasting of jet stream and cold LOW developments. For long-range planning purposes, current climatological data is only tentative but this deficiency is already being corrected.

(*3*) *Turbulence.*—This element is likely to pose a complex and continuing problem for the forecaster until we learn some of the answers from an accumulation of operational experience.

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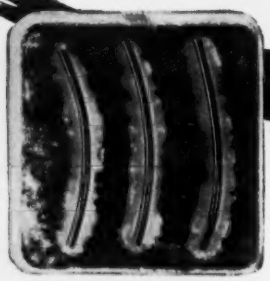

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Summaries of Current Papers Accepted for I.A.S. Publications

Buckling of Sandwich Cylinders Under Axial Compression

By

F. K. Teichmann, Chi-Teh Wang, and George Gerard

New York University

A theory for the buckling of the sandwich cylinders under axial compression is formulated, and the resulting differential equations are solved. Both the symmetrical and general circumferential buckling are considered. For long cylinders, the results of these two theories agree with each other as in the case of the buckling of homogeneous circular cylinders. The buckling stress is presented in a nondimensional form in terms of parameters that are characteristic of the sandwich cylinders. The theory is verified experimentally for sandwich cylinders constructed of a core material that is weak in shear.

Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities—I

By

P. P. Bijlaard

Cornell University

The author gives a detailed but simple derivation of his formula of the critical thrust for antisymmetrical buckling of sandwich plates

$$P_{cr} = P_0 + (P_1^{-1} + P_2^{-1})^{-1}$$

in which P_0 is the joint critical thrust of the single faces (Case 0), P_1 is the critical thrust without taking account of the shear deformation of the core (Case 1), and P_2 obtains if only shear deformations of the core would occur (Case 2). In computing P_1 and P_2, the flexural rigidity of the faces is not taken into account.

The method is applied to twelve different cases of loading and boundary conditions, for which the reduction coefficients for buckling in the plastic domain are also given and presented in graphs. A detailed explanation is included showing how the resulting formulas must be used to find the critical load P_{cr}. The critical load P_{crw} for wrinkling of the faces is also considered.

Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method

By

James B. Rea

Douglas Aircraft Company, Inc. (Santa Monica)

The purpose of the paper is to outline a method for determining in a single analysis the aircraft flight-path stability, the dynamic tail loads, and the flutter response of the system. This method treats the airplane itself as a servomechanism and is called the Transfer Function-Fourier (TFF) method.

The TFF method is first explained in general, followed by simple examples to demonstrate the concept of the Transfer Function and the use of the Fourier technique in obtaining the transient response. Also included is a brief summary of the history leading to the development of the TFF method in the field of automatic control. Examples are then given to show the conventional application of this method to the dynamic stability analysis of simple feedback servomechanisms and automatic control systems.

The paper then points out that, through extension of these fundamental concepts, an aeroelastic aircraft may be analyzed dynamically by treating it as a multiple loop servomechanism with aerodynamic and aeroelastic feedbacks. This allows many of the methods and "tools" that were developed years ago by the electrical-servomechanism engineers in their study of the dynamic stability of communication networks, feedback amplifiers, servomechanisms, and automatic control systems to be applied directly by the TFF method to the dynamic analysis of aeroelastic aircraft. The paper also points out that many of the analysis techniques recently developed in the study of the dynamics of aeroelastic aircraft by conventional methods, especially the matrix techniques developed in the field of flutter, may be applied to the dynamic analysis of systems for automatic control.

Practical examples are then given to demonstrate the extension of the TFF method to the dynamic analysis of rigid-body and aeroelastic aircraft. These examples include:

(a) A rigid-body longitudinal dynamic analysis of an airplane to determine the transient maneuvering tail loads developed by elevator displacements.

(b) A longitudinal dynamic stability and performance analysis (and a limited flutter analysis) of an airplane equipped with a mechanical gust load alleviation system that is actuated by elastic wing deflection.

(c) A longitudinal dynamic analysis of an airplane to determine by a single analysis: (1) the stability of the aircraft flight path, (2) the dynamic tail loads, and (3) the flutter response of the control system and the multielastic structure, where these responses result from arbitrary gust disturbances or control force inputs. (This more complete analysis includes the degrees of freedom of the airplane as a whole, its control system, its multielastic structure, and aerodynamic circulation.)

In conclusion, the paper points out the main advantages of the TFF method and makes recommendations for further study and development of the method.

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Negative Camber Airfoils for Transonic Flight

By

Thomas B. Woersching

The Glenn L. Martin Company

The potentialities of negative camber as a means of increasing airfoil M_c's are pointed out and substantiated by the negative lift range of available unclassified transonic test data for positive camber airfoils. The use of W camber for transonic airfoils is proposed as a practical refinement of the S camber that yields the highest possible M_c but suffers from intolerably large negative values of C_m.

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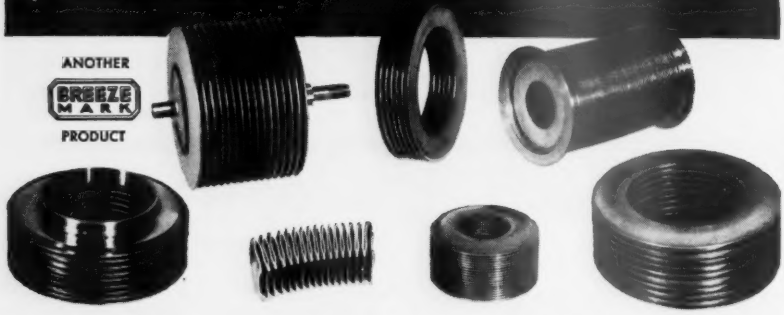

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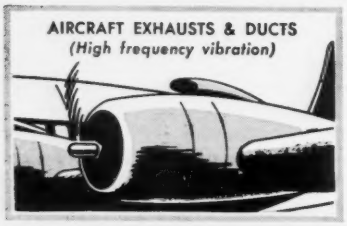

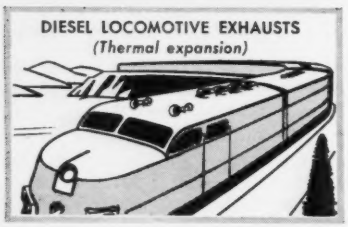

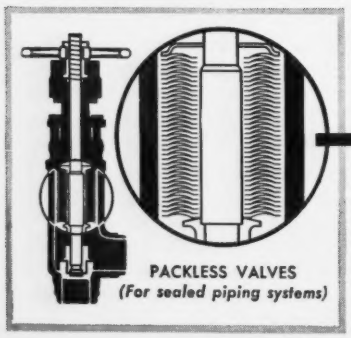

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The theoretical characteristics at $M_0 = 0$ of two W camber airfoils derived for use at transonic M_0's are presented. The estimated M_c's are about 0.864 at $C_l = 0.2$.

On Turbulent Fluid Motion

By
Max M. Munk
Naval Ordnance Laboratory

Turbulent fluid motion is a daily and common experience, and still it comes as a surprise to the inquisitive student of hydrodynamics. It came to him as a surprise even in the early period of boundary-layer study at a time when the possibility of turbulence had already been well recognized. By now we are resigned to the frequent occurrence of turbulence but have still to suppress the feeling of slight mental frustration or incongruence whenever we give serious thought to it. In spite of half a century of intense mathematical effort, the frequent instability of laminar flow is not clearly understood, and turbulence has not been laid bare as a simple consequence of the kinematics and dynamics involved. So far it has been denied to our inquisitive minds to see turbulence clearly, distinctly, and intuitively as a direct consequence of the underlying laws of motion.

There are presented in this paper some broad thoughts toward clarification of the turbulence problem. There are thoughts that may perhaps suggest to one or the other reader a more precise and perhaps more heuristic inquiry. These thoughts do not fully satisfy. They carry the inquiry forward without bringing it to full conclusion. Still they set the mind a little bit at ease and blunt the edge of consternation and frustration.

The arguments will be chiefly directed to the straight channel flows of the incompressible fluid, which are the plane Couette flow and the Poiseuille flow. These are the simplest cases, but the territory of inquiry is much broader and the thoughts presented are, indeed, fairly general. Also, in this paper, it will not be necessary to give much attention to the three-dimensional aspect of the flow; the present issue is basically two-dimensional. Actual turbulence is, of course, always three-dimensional.

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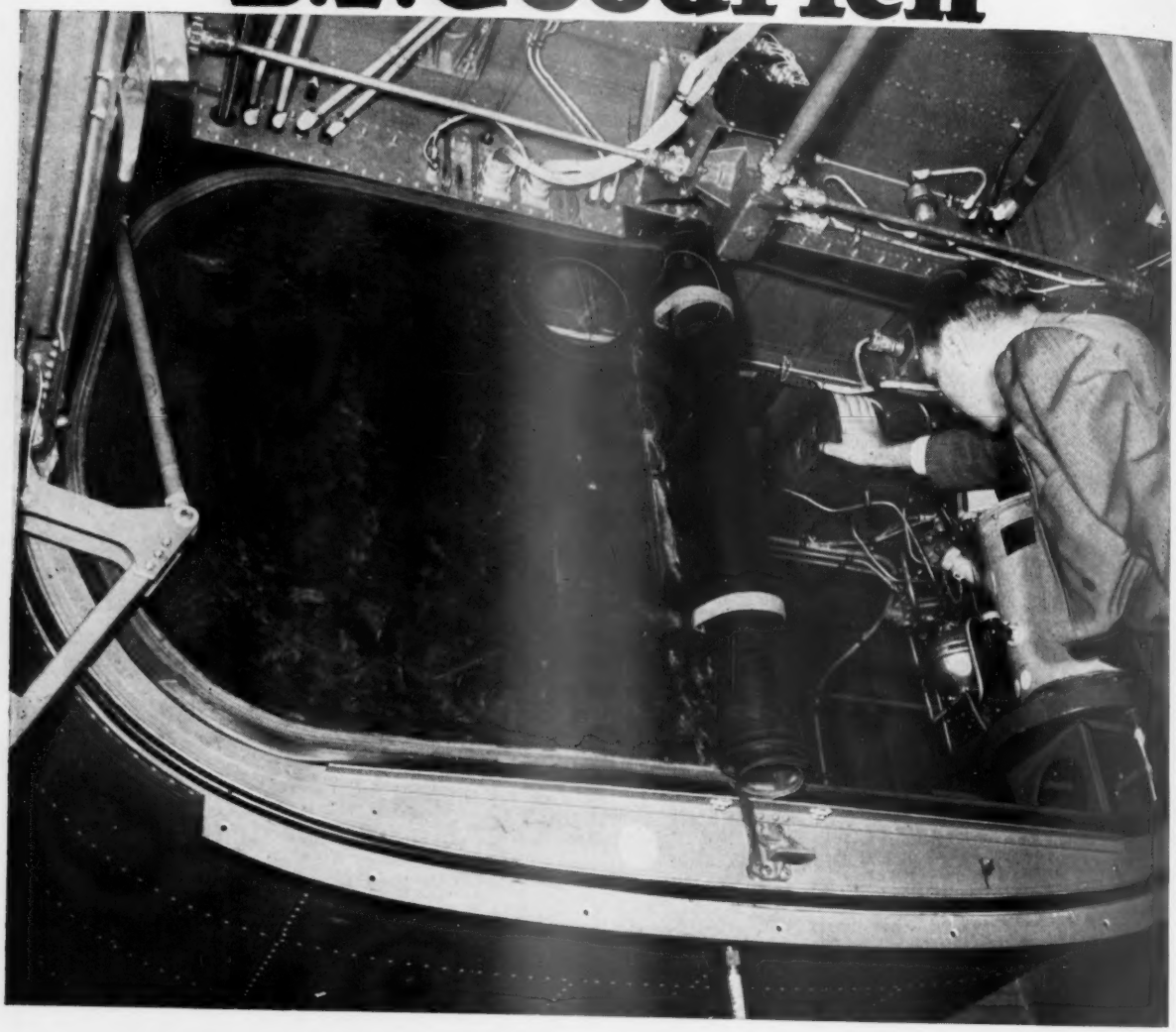

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Aerodynamics (2)

BOUNDARY LAYER

The Interaction Between an Oblique Shock-Wave and a Turbulent Boundary-Layer. O. Bardsley and W. A. Mair. *Philosophical Magazine*, Vol. 42 (7th Series), No. 324, January, 1951, pp. 29–36, illus. 4 references.

Experiments were made in an intermittent supersonic wind tunnel at $M = 1.965$ using a double-wedge airfoil. Schlieren photographs were made to show the reflection of oblique shock waves of different strengths at the turbulent boundary layer on the tunnel wall; the shock strength was varied by changing the incidence of the model. Descriptions of the wind tunnel and the schlieren apparatus are included.

Turbulent Boundary Layer in Compressible Fluids. E. R. Van Driest. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 145–160, 216, illus. 16 references.

Derivation of a general formula for skin friction, including heat transfer to a flat plate for a thin, fully turbulent boundary layer in compressible fluids with zero pressure gradient.

A New Form of Solution of Hermite's Equation. W. A. Mersman. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 191–197. 4 references.

A study of a modified form of Hermite's equation which occurs in the study of the laminar boundary layer of a compressible fluid over a heated flat plate to obtain a solution that is tractable to numerical methods of computation. The method is applicable to any linear homogeneous differential equation of the second order to obtain a second solution when one is already known.

Additional Measurements of the Drag of Surface Irregularities in Turbulent Boundary Layers. W. Tillmann. (*ZWB, Untersuchungen und Mitteilungen Nr. 6619*, December 27, 1944.) *U.S., N.A.C.A., Technical Memorandum No. 1299*, January, 1951. 35 pp., illus. 4 references.

The Use of a Luminescent Lacquer for the Visual Indication of Boundary-Layer Transition. Jackson R. Stalder and Ellis G. Slack. *U.S., N.A.C.A., Technical Note No. 2263*, January, 1951. 17 pp., illus. 5 references.

Visual determination of the boundary-layer transition point is achieved by means of a phosphor pigment mixed wth a lacquer, which fluoresces with a bright yellow color under irradiation by ultra-violet light when dry and exhibits no fluorescence when wet.

Some Improvements in the Design of Thick Suction Aerofoils. J. Williams. *Gt. Brit., Aeronautical Research Council, Current Papers No. 31*, March 8, 1950. 17 pp., illus. 9 references. British Information Services, New York. $0.50.

Investigation of two theoretical methods for representing closely the physical conditions at the slot. One analysis takes into account the sink effect due to suction at the slot and the shape of the slot; the other excludes the sink effect.

Some Characteristics of a Turbulent Boundary Layer in the Vicinity of a Suction Slot. R. A. Wallis. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Aerodynamics Note No. 87*, May, 1950. 53 pp., illus. 23 references.

Tests to establish the flow characteristics in the vicinity of a suction slot were made in a duct with a cross section of 12 by 4 in. at a speed of 30 ft. per sec. The boundary-layer thickness at the slot was approximately 0.6 in. on the test surface and 0.4 in. on the side walls. The work was done in conjunction with design studies of an aircraft using a Griffith-type airfoil.

CONTROL SURFACES

Theoretical Symmetric Span Loading Due to Flap Deflection for Wings of Arbitrary Plan Form at Subsonic Speeds. John DeYoung. *U.S., N.A.C.A., Technical Note No. 2278*, January, 1951. 71 pp., illus. 5 references.

A simplified lifting-surface theory is applied, and the loading is obtained by the solution of four simultaneous equations. The coefficients of the equations are given in charts as functions of parameters of wing geometry, compressibility, and section lift-curve slope. Flap effectiveness is determined by use of integration formulas for the loading distributions.

Flight Investigation of the Effects of Various Vertical-Tail Modifications on the Directional Stability and Control Characteristics of a Propeller-Driven Fighter Airplane. Harold I. Johnson. *U.S., N.A.C.A., Report No. 973*, 1950. 19 pp., illus. 5 references. U. S. Govt. Printing Office, Washington. $0.20.

Flight investigations of six vertical-tail configurations to determine the lateral-direction oscillation characteristics, sideslip characteristics, yaw due to ailerons in rudder-fixed rolls from turns and pull-outs, trim changes due to speed changes, and trim changes due to power changes.

Low-Speed Wind Tunnel Tests of a High-Lift Supersonic Wing. W. S. D. Marshall, I. Levaćić, A. D. Young, and G. J. Powter. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2364*, 1950 (September, 1946). 24 pp., illus. 8 references. British Information Services, New York. $1.15.

Results of wind-tunnel tests on a rectangular wing of biconvex section 7.5 per cent thick, fitted with a flap and a leading-edge slot. The flap, of the semislotted Fowler type, has a chord equal to 0.25 of the wing chord and is set at 46°. The forward 16 per cent of the wing forms the slat. Tests were made with the slat moved forward and rotated through various angles. The model was also fitted with plain front and rear flaps. The basic configuration, and the wings with the slats and flaps, were tested at speeds of 80 and 120 ft. per sec. C_L, C_D, and C_M were tabulated for various slat settings.

Two-Dimensional Tests on a 15 Per Cent Thick Symmetrical Roof-Top Aerofoil with 20 Per Cent Plain Flap in the National Physical Laboratory 13 Ft. × 9 Ft. Wind Tunnel. F. Cheers, W. S. Walker, and C. R. Taylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2412*, 1950 (June 24, 1946). 10 pp., illus. 11 references. British Information Services, New York. $0.50. Wing and flap were tested at speeds up to 180 ft. per sec. to obtain information about the low drag range obtained with flap deflection.

Tests on a 5-Per Cent Biconvex Aerofoil in the Compressed Air Tunnel. D. H. Williams and A. H. Bell. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2413*, 1950 (October 19, 1945). 10 pp., 1 reference. British Information Services, New York. $0.50. A symmetric 5 per cent biconvex airfoil was tested at a Reynolds Number range of 0.3×10^6 to 7.5×10^6 with and without a 15 per cent split flap. Test results are tabulated.

FLUID MECHANICS & AERODYNAMIC THEORY

Notes on the Linearized Equation for the Velocity Potential of the Steady Supersonic Flow of a Compressible Fluid. R. K. Tempest and L. Rosenhead. **Note.** W. N. Bailey. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 3, March 20, 1947, March 17, 1949, pp. 197–212, 213, 214. 11, 2 references.

Review of the physical background for the linearized differential equation of the velocity potential of a compressible fluid in steady supersonic flow. The applications of known solutions of the wave equation are given physical interpretations in supersonic flow. Two new solutions appropriate to systems of conical and wedge coordinates are derived.

Retarded Potentials of Supersonic Flow. J. C. Martin. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 358–364. 4 references.

A formula is derived for the velocity potential at any point in space when the conditions on the disturbing surface are given. Since the study is based on the linearized partial differential equation, the disturbances are small.

A Study of Second-Order Supersonic-Flow Theory. Milton D. Van Dyke. *U.S., N.A.C.A., Technical Note No. 2200*, January, 1951. 73 pp., illus. 33 references.

Determination of Axially Symmetric Flow Patterns of a Compressible Fluid. S. Bergman. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 133–145, illus. 12 references.

Analysis of the equation for the potentials of axially symmetric flows. The nonlinear equation $(\Phi - \Phi^{(0)})$ is solved by the method of successive approximations and is replaced by a sequence of linear nonhomogeneous equations. The sub- and supersonic regions are investigated simultaneously, and solutions are obtained for the mixed case. A method is given for setting up tables for computing the first and second approximations.

An Axial-Symmetric Transonic Flow Pattern. G. Guderley and H. Yoshihara. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 333–339, illus. 4 references. (Condensed version of *U.S., Air Force, Technical Report No. 5783.*) An axial-symmetric flow pattern at free-stream Mach Number = 1 is investigated on the basis of a study of the flow at infinity in a physical plane.

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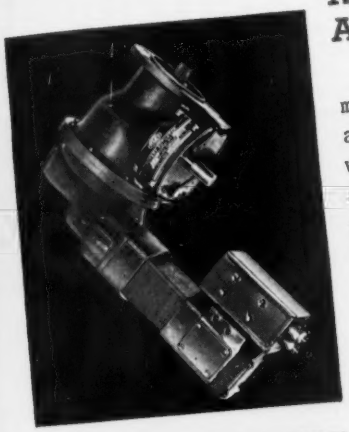

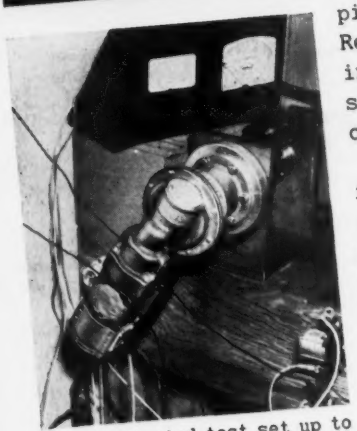

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The Invariant Theory of Isotropic Turbulence in Magneto-Hydrodynamics. S. Chandrasekhar. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 204, No. 1079, January 4, 1951, pp. 435–449, illus. 12 references. The invariant theory of isotropic turbulence is developed on the basis of Batchelor's equations of motion for the hydrodynamics of an incompressible fluid that is also a good conductor.

First- and Second-Order Theory of Supersonic Flow Past Bodies of Revolution. Milton D. Van Dyke. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 161–178, 216, illus. 26 references.

Readers' Forum: Thickness of a Steady Shock Wave. J. J. Bernard. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, p. 210, illus. 3 references.

Die linearisierte Theorie der dreidimensionalen kompressiblen Unterschallströmung und die experimentelle Untersuchung von Rotationskörpern in einem geschlossenen Windkanal. Edward R. Van Driest. *Zurich, Eidgenössische Technische Hochschule, Institut für Aerodynamik, Mitteilungen Nr. 16*, 1949. 31 pp., illus. 14 references. Verlag Leemann, Zurich. Sw. Fr. 7.–. In German.

The linearized theory is first developed for high subsonic flow along slender three-dimensional bodies. A rule is stated by which the compressible flow pressure on any given slender body may be calculated to the first-order approximation. The theory is then applied to obtain the pressure distribution along ellipsoids and halfbodies of revolution in the free stream. Even though the tunnel corrections are large compared to the free-stream compressibility effects, the theory agrees rather well with the data.

The Rankine Gas Flow in the Hodograph Plane. Max M. Munk. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 387–392. 4 references. The hodograph solution is set up for the flow of a perfect gas of subsonic velocity which flows past the head of an obstacle extending infinitely far downstream.

Influence of Reynolds Number on the Separation (Cavitation) Flow. V. A. Konstantinov. (*Akademiia Nauk S.S.S.R., Leningrad, Otdelenie Tekhnicheskikh Nauk, Izvestiia*, 1946, No. 10, pp. 1355–1373.) *U.S., Navy Department, David W. Taylor Model Basin, Translation No. 233*, November, 1950. 20 pp., illus.

A preliminary, qualitative study. Six circular cylinders of 5, 10, 20, 30, 40, and 50 mm. diameter were tested in the cavitation tunnel, and test results were analyzed. A short description of the water tunnel and experimental methods is given.

INTERNAL FLOW

Experimental Investigation of a Stationary Cascade of Aerodynamic Profiles. William T. Sawyer. *Zurich, Eidgenössische Technische Hochschule, Institut für Aerodynamik, Mitteilungen Nr. 17*, 1949. 78 pp., illus. 46 references. Verlag Leemann, Zurich. Sw. Fr. 12.–. In English.

The effects of Reynolds Number and turbulence on a cascade were measured at low speed. The cascade was designed on the basis of Ackeret's continuum theory. Steps in the design of the cascade and in the testing and calibrating of the wind tunnel and its instruments and balances are explained. Two-dimensional and three-dimensional tests were made, and the tests results compared with theory. Results verified the accuracy of Ackeret's theory.

Two-Dimensional Compressible Flow in Centrifugal Compressors with Logarithmic-Spiral Blades. Gaylord O. Ellis and John D. Stanitz. *U.S., N.A.C.A., Technical Note No. 2255*, January, 1951. 46 pp., illus. 4 references.

Two numerical solutions are obtained for the two-dimensional compressible nonviscous flow in centrifugal compressors with backward-curved logarithmic-spiral blades for two different blade angles. Solutions are compared with the solution for straight radial blades. Design and operating parameters are identical for the three cases.

Investigations of Axial-Flow Compressors. J. T. Bowen, R. H. Sabersky, and W. D. Rannie. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 1–15, illus. 15 references.

Outline of a theory for computing the flow through axial compressors. This theory is verified by a comparison of measured and calculated internal-flow problems, studies in cascade losses, and the interaction of wall and cascade boundary layers.

PARASITIC COMPONENTS & INTERFERENCE

Wind-Tunnel Tests on the Exhaust and Propeller Interference Drag of a Merlin Universal Power Plant Installed on a Wing. K. G. Winter and J. Dorward. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2374*, 1950 (August, 1946). 41 pp., illus. 3 references. British Information Services, New York. $1.70.

One-fifth scale model nacelles fitted on a 20 per cent thick wing were tested in the R.A.E. 11½-ft. wind tunnel to determine the interference drag of the nacelles with various exhaust positions. Interference effects of the installation with a propeller were also investigated.

PERFORMANCE

Performance of (Grumman) Goose 2 Aircraft. I—Operational Report. E. Miall and M. T. Friedl. *Canada, Royal Canadian Air Force, Experimental and Proving Establishment, Rockcliffe, Report No. 928* [*Final Development Report No. D104(1)-1*], December, 1950. 35 pp., illus.

STABILITY & CONTROL

A Survey of Stability Analysis Techniques for Automatically Controlled Aircraft. Arthur L. Jones and Benjamin R. Briggs. *U.S., N.A.C.A., Technical Note No. 2275*, January, 1951. 112 pp., illus. 53 references.

A survey and evaluation of stability analysis techniques that are commonly applied to linear continuous-control systems in which the difference between input and output quantities is measured continuously and is used in the operation of a closed-loop system. The calculations are carried out for a typical high-speed fighter aircraft having an automatic pilot.

A Theoretical Analysis of the Effects of Fuel Motion on Airplane Dynamics. Albert A. Schy. *U.S., N.A.C.A., Technical Note No. 2280*, January, 1951. 53 pp., illus. 9 references.

Readers' Forum: On the Equations of Longitudinal Stability. II. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, p. 212. 1 reference.

Readers' Forum: The Application on Nonstationary Airfoil Theory to Dynamic Stability Calculations. E. V. Laitone and E. R. Walters. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 214–216, illus. 5 references.

THERMOAERODYNAMICS

Note on Aerodynamic Heating. H. W. Emmons. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 402–404, illus. 2 references.

Analysis of the temperature distribution resulting from the energy dissipated in the acceleration of an initially stationary semifinite viscous fluid by the sudden starting from rest of the infinite bounding plane at velocity U parallel to the plane.

WINGS & AIRFOILS

Some Theoretical Low-Speed Span Loading Characteristics of Swept Wings in Roll and Sideslip. John D. Bird. *U.S., N.A.C.A., Report No. 969*, 1950. 15 pp., illus. 16 references. U.S. Govt. Printing Office, Washington. $0.20.

The Weissinger method for determining additional span loading for incompressible flow is used to find the damping in roll, the lateral center of pressure of the rolling load, and the span loading coefficients caused by rolling for wing plan forms of various aspect ratios, taper ratios, and sweep angles. Experimental data are given for the verification of some of the results. The applicability of the method to certain other derivatives is indicated.

Rolling and Yawing Moments for Swept-Back Wings in Sideslip at Supersonic Speeds. Seymour Lampert. *U.S., N.A.C.A., Technical Note No. 2262*, January, 1951. 55 pp., illus. 12 references.

Formulas are derived by use of methods of linearized nonviscous conical-flow theory for computing the rolling and yawing moments of flat, thin, sweptback wings that have subsonic edges.

The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed. C. W. Frick and R. S. Chubb. *U.S., N.A.C.A., Report No. 965*, 1950. 12 pp., illus. 11 references. U.S. Govt. Printing Office, Washington. $0.15.

Calculation of the longitudinal stability characteristics at supersonic speed of high-aspect-ratio elastic swept wings experi-

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encing bending and torsional deformations. The method uses the linearized lifting-surface theory and assumes a parabolic wing-deflection curve. The analysis applies to wings whose leading edges are swept behind the Mach lines; the trailing edge is sonic or supersonic.

Theoretical Damping in Roll and Rolling Effectiveness of Slender Cruciform Wings. Gaynor J. Adams. *U.S., N.A.C.A., Technical Note No. 2270,* January, 1951. 30 pp., illus. 13 references.

The rolling-moment characteristics are investigated by a method based on low-aspect-ratio wing theory. The method may be applied to slender cruciform wing problems that have arbitrarily assigned boundary conditions. A conformal transformation is given which may be used to determine the moment characteristics of a rotationally symmetric slender-wing configuration consisting of any number of plane wings having a common chord.

Airfoil Profiles for Minimum Pressure Drag at Supersonic Velocities; General Analysis with Application to Linearized Supersonic Flow. Dean R. Chapman. *U.S., N.A.C.A., Technical Note No. 2264,* January, 1951. 38 pp., illus. 10 references.

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Low-Speed Wind Tunnel Tests of a High-Lift Supersonic Wing. W. S. D. Marshall, I. Levaćić, A. D. Young, and G. J. Powter. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2364,* 1950 (September, 1946). 24 pp., illus. 8 references. British Information Services, New York. $1.15.

Results of wind-tunnel tests on a rectangular wing of biconvex section 7.5 per cent thick, fitted with a flap and a leading-edge slot. The flap, of the semislotted Fowler type, has a chord equal to 0.25 of the wing chord and is set at 46°. The forward 16 per cent of the wing forms the slat. Tests were made with the slat moved forward and rotated through various angles. The model was also fitted with plain front and rear flaps. The basic configuration and the wings with the slats and flaps were tested at speeds of 80 and 120 ft. per sec. C_L, C_D, and C_M were tabulated for various slat settings.

Methods for Calculating the Flow in the Trefftz-Plane Behind Supersonic Wings. P. A. Lagerstrom and Martha E. Graham. (*Douglas Aircraft Company, Inc., Report No. SM-13288,* July 28, 1948.) *Journal of the Aeronautical Sciences,* Vol. 18, No. 3, March, 1951, pp. 179–190, illus. 5 references.

Purely Rolling Oscillations of a Rectangular Wing in Supersonic Flow. Ting-Yi Li. *Journal of the Aeronautical Sciences,* Vol. 18, No. 3, March, 1951, pp. 191–198, illus. 2 references.

Development of a method of solution and presentation of some numerical results. Vector diagrams are constructed of the rolling moments acting on wings of aspect ratios of $1/\beta$, 1, 3, 5, and ∞; $M = 10/7$, 2; and a frequency range of $0 \leq k_c \leq 2.0$.

Similarity Laws for Transonic Flow About Wings of Finite Span. John R. Spreiter. *U.S., N.A.C.A., Technical Note No. 2273,* January, 1951. 24 pp., illus. 15 references. Laws are based on the equations of transonic small-perturbation theory.

Quasi-Stationary Airfoil Theory in Subsonic Compressible Flow. John W. Miles. *Quarterly of Applied Mathematics,* Vol. 8, No. 4, January, 1951, pp. 351–358, illus. 11 references.

Determination of the pressure distribution on a two-dimensional thin airfoil in compressible flow for the case where the prescribed downwash distribution exhibits a low-frequency harmonic time dependency. The solution is obtained by retaining only the first-order terms in frequency. The damping derivative of a tail in rotary motion about a forward center is calculated; the damping is less than that calculated by stationary airfoil theory.

An Improved Approximate Method for Calculating Lift Distributions Due to Twist. James C. Sivells. *U.S., N.A.C.A., Technical Note No. 2282,* January, 1951. 35 pp., illus. 13 references.

The method is based on the lifting-line theory and uses the lift distribution due to angle of attack and wing aspect ratio. Expressions are obtained for symmetric, antisymmetric, continuous, and discontinuous types of twist. This analysis is extended to cover swept wings.

Readers' Forum: Note on the Relation of Lifting-Line Theory to Lifting-Surface Theory. Eric Reissner. *Journal of the*

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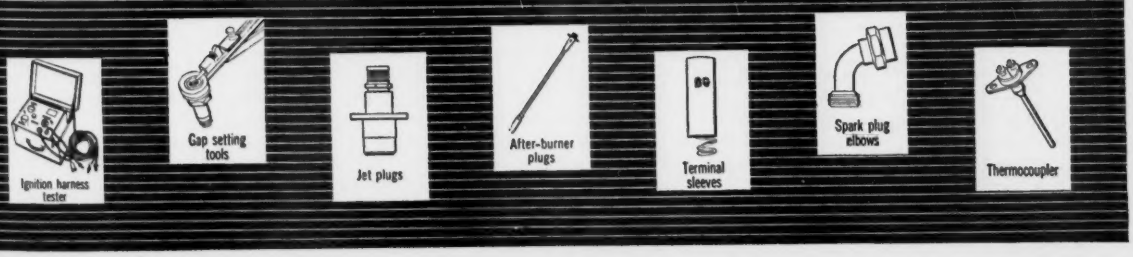

Aeronautical Sciences, Vol. 18, No. 3, March, 1951, pp. 212–214. 4 references.

Force and Pressure Coefficients up to Mach Number 0.87 on the Goldstein Roof-Top Section 1442/1547. H. H. Pearcey and J. A. Beavan. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2346*, 1950 (April, 1946). 25 pp., illus. 8 references. British Information Services, New York. $1.25. Tests on a 14 per cent thick low-drag airfoil in the 20- by 8-in. N.P.L. rectangular high-speed tunnel at $M = 0.4$–0.87, at $R = 1.1$–1.9×10^6, and at incidence of $-2.5°$ to $6.5°$.

Two-Dimensional Tests on a 15 Per Cent Thick Symmetrical Roof-Top Aerofoil with 20 Per Cent Plain Flap in the National Physical Laboratory 13 Ft. × 9 Ft. Wind Tunnel. F. Cheers, W. S. Walker, and C. R. Taylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2412*, 1950 (June 24, 1946). 10 pp., illus. 11 references. British Information Services, New York. $0.50. Wing and flap were tested at speeds up to 180 ft. per sec. to obtain information about the low drag range obtained with flap deflection.

Some Improvements in the Design of Thick Suction Aerofoils. J. Williams. *Gt. Brit., Aeronautical Research Council, Current Papers No. 31*, March 8, 1950. 17 pp., illus. 9 references. British Information Services, New York. $0.50.

Investigation of two theoretical methods for representing closely the physical conditions at the slot. One analysis takes into account the sink effect due to suction at the slot and the shape of the slot; the other excludes the sink effect.

The Effects of Variations in Reynolds Number Between 3.0×10^6 and 25.0×10^6 upon the Aerodynamic Characteristics of a Number of NACA 6-Series Airfoil Sections. Laurence K. Loftin, Jr., and William J. Bursnall. *U.S., N.A.C.A., Report No. 964*, 1950. 20 pp., illus. 9 references. U.S. Govt. Printing Office, Washington. $0.20.

Air Transportation (41)

Delay in Commercial Jet Transport. M. G. Beard. *Air Affairs*, Vol. 3, No. 3, December, 1950, pp. 569–575.

The reluctance of U.S. air lines to purchase jet transports is based chiefly on the fact that, while the jet transport and jet engine are basically simple, their safe and dependable operation depends on the reliability of many complex auxiliary devices. The problems concerned with engine operation, navigation, pressurization, refrigeration, and control devices are considered in detail, and possible solutions are suggested.

United's Evaluation of Turbine Transports. J. A. Herlihy. *American Aviation*, Vol. 14, No. 25, January 8, 1951, pp. 25, 26, 30, 32, illus.

A study of three transports: a 40-passenger, twin-engined transport powered by reciprocating engines, a similar transport with turboprop engines, and a four-engined turbojet transport having an equivalent passenger capacity to determine and compare their potential earning capacities.

Airline Finance. Harvey J. Gunderson. *Air Affairs*, Vol. 3, No. 3, December, 1950, pp. 509–516. Trends in air-line financing, chiefly the problems associated with the acquisition of new aircraft, due to events of the past few years and military needs.

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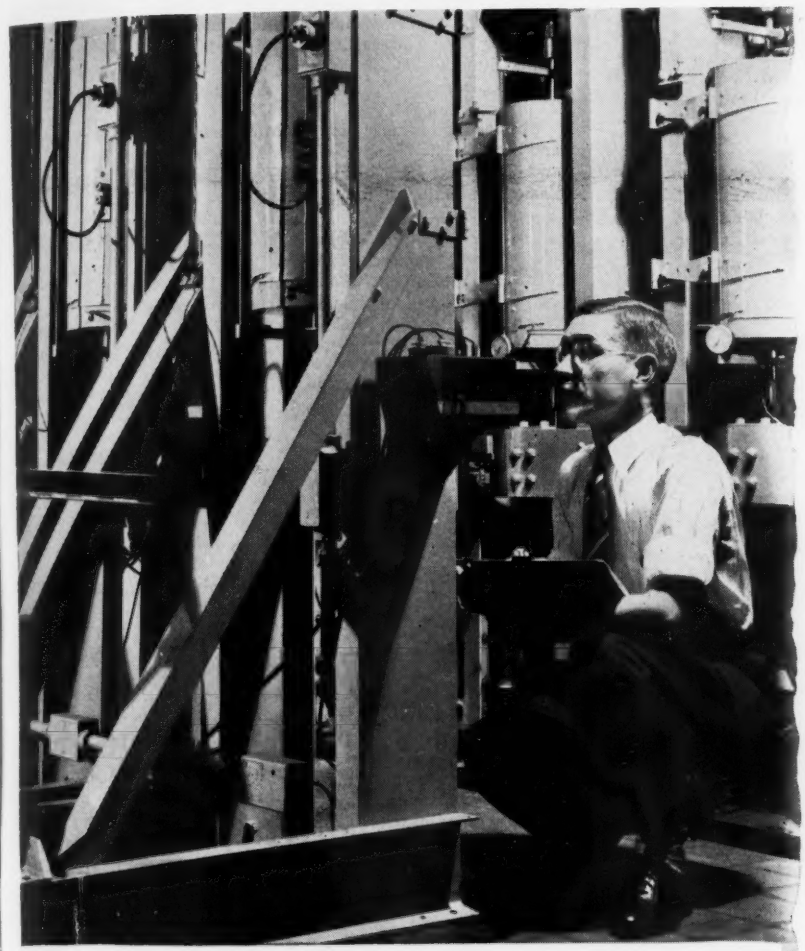

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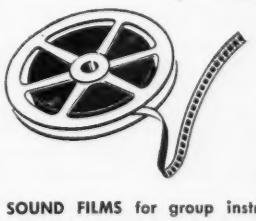

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Education & Training (38)

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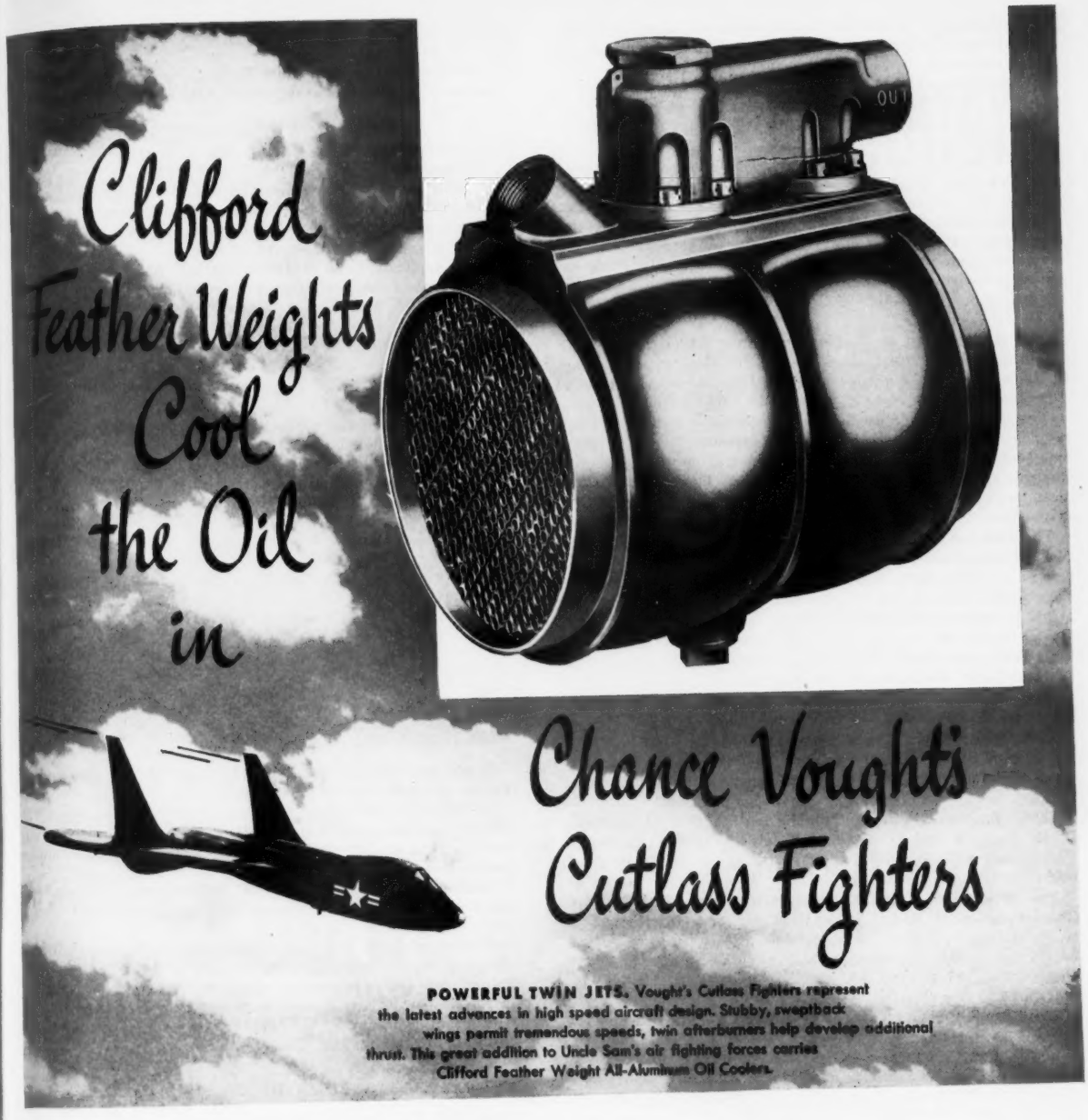
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A Multichannel PAM-FM Radio Telemetering System. J. P. Chisholm, E. F. Buckley, and G. W. Farnell. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 1, January, 1951, pp. 36–43, illus. 7 references.

Two 8-channel multiplexers provide 16 information channels and 6,400 data samples per sec.; each channel has a frequency response of 0–3,200 cycles per sec. Pulse amplitude modulation and time-division multiplexing are performed by pentode gating tubes supplied with the appropriate gating pulse from a compact crystal-resistor matrix. Relatively few modifications are required to vary either the number of channels or the maximum frequency response per channel. Potted-unit construction is used on the air-borne unit.

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Equipment

ELECTRICAL (16)

High Ambient Temperatures Encountered in Present and Future Aircraft. D. M. Patterson. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 1, January, 1951, pp. 19–21, illus. Problems confronting the electrical equipment manufacturer because of high ambient temperatures of supersonic flight.

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HYDRAULIC & PNEUMATIC (20)

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An electronic gage for checking hydraulic pressure. A Wheatstone bridge provides an electrical output that is proportional to the pressure applied to the pickup; a cathode-ray tube displays rapid pressure changes. Pressure may be plotted against time, movement, or temperature.

An Interesting Flow-Valve. *The Aeroplane*, Vol. 80, No. 2059, January 5, 1951, p. 27, illus.

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Turbine-Engine Anti-Icing Tested Atop Mt. Washington. P. M. Bartlett and T. A. Dickey. *SAE Journal*, Vol. 59, No. 1, January, 1951, pp. 25–28, illus. (Excerpts from a paper.)

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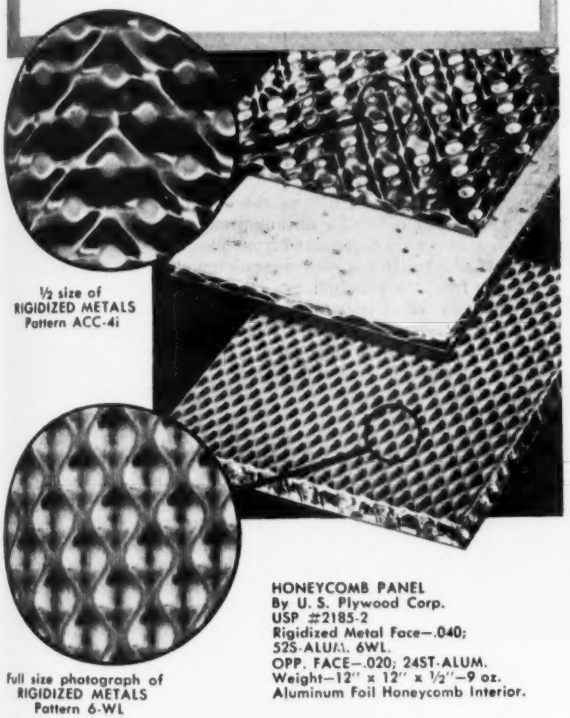

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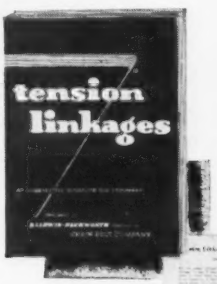

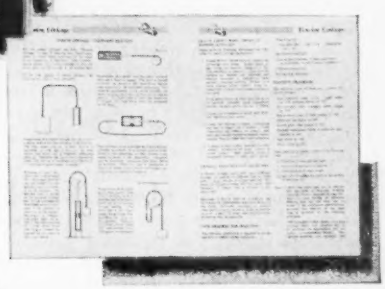

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Porous Panel Anti-Icing System. *Aviation Week*, Vol. 54, No. 2, January 8, 1951, pp. 35, 36, illus.

Development, by T.K.S. (Aircraft De-Icing) Ltd., of sintered bronze strips (Porosint) that enable "Killfrost" deicing fluid to seep through onto the leading edges of wings and tail.

New Methods of De-Icing for Wings and Tailplanes. *Interavia*, Vol. 5, No. 12, December, 1950, pp. 644–646, illus. The T.K.S. (Aircraft De-Icing) Ltd. fluid system.

REFUELING IN FLIGHT

Transport Refueling. Burgess Clark. *Aero Digest*, Vol. 62, No. 1, January, 1951, pp. 56, 58, 59, 73, illus. Future possibilities of flight refueling for air-line traffic.

Flight Safety & Rescue (15)

Observations on Flight Safety. Jerome Lederer. *S.A.E., Annual Meeting, Detroit, January 8–12, 1951, Preprint No. 552.* 33 pp.

The problems of economic pressure and safety; attitude on safety measures; statistics and safety; operating vexations, competition, and safety; and politics and safety in the development of safer air travel.

Seating Innovation Stirs Industry Interest. *American Aviation*, Vol. 14, No. 27, January 22, 1951, pp. 28, 29, illus.

The Bennett hammock-type aircraft seat built by Aerotherm Corp., Bantam, Conn. The entire seat swings freely between two large tear-drop-shaped flat springs that form the outer panels of the seat. The passenger controls his seat position merely by shifting his weight; the center of gravity is always below the pivot point of the hammock. In case of an accident, the seat puts the passenger in a position to withstand a maximum-impact load.

How to Increase Safety in Scheduled Air Operations. T. P. Wright. *SAE Journal*, Vol. 59, No. 1, January, 1951, pp. 35–41. (Excerpts from a paper: Research and Development to Promote Safety in Aviation.)

Effectiveness of Ejection Seat Training with Special Reference to SDC Device 6EQ-2. Richardson, Bellows, Henry & Co., Inc. *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 383-5-1*, November 15, 1950. 19 pp.

The Device 6EQ-2 (ejection seat trainer) was designed on the basis of experience with the Research Tower (developed by Martin-Baker Aircraft Ltd.) to aid in the indoctrination of pilots in the use of the ejection seat. A comparison of the two devices (from the results of questionnaires to pilots) indicates that the 6EQ-2 is as effective as the Research Tower.

Improved Pilot Shoulder Harnesses Withstand 38.6 G Crashes. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 1, January, 1951, p. 8, illus.

The pilot harness has an inverted "V" crossing the pilot's thighs, thus allowing the thighs and shoulders to take more of the stress and relieving the pressure across the upper abdomen.

Inerting of Aircraft Fuel Tanks with Carbon Dioxide Prior to Fuel Tank Repair Operations. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 56-A*, January 10, 1951. 9 pp. 9 references.

The Utilization of Airline Employees as Volunteers for Ground Aircraft Fire Fighting at Airports. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 61*, January 11, 1951. 4 pp.

Flight Testing (13)

A Radar Method of Calibrating Airspeed Installations on Airplanes in Maneuvers at High Altitudes and at Transonic and Supersonic Speeds. John A. Zalovcik. *U.S., N.A.C.A., Report No. 985*, 1950. 7 pp., illus. U.S. Govt. Printing Office, Washington. $0.15.

This method of calibrating the static-pressure source of a Pitot-static air-speed indicator involves the use of radar tracking equipment to establish the geometric altitude of the airplane.

Notes on the Turning Performance of the Spitfire as Affected by Altitude and Flaps. M. B. Morgan and D. E. Morris. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2349*, 1950 (April, 1941). 15 pp., illus. 5 references. British Information Services, New York. $0.75.

Messerschmitt Me.109 Handling and Manoeuverability Tests. M. B. Morgan and D. E. Morris. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2361*, 1950 (September, 1940). 36 pp., illus. 13 references. British Information Services, New York. $1.60.

Handling Tests on the Curtiss H-75, and Comparative Aileron Tests on the Curtiss H-75, Spitfire and Gloster F.5/34. M. B. Morgan, D. E. Morris, and F. J. Bigg. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2379*, 1950 (April, 1940). 33 pp., illus. 9 references. British Information Services, New York. $1.40.

Research Handling Tests on "Blenheim" L6595. M. B. Morgan. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2348*, 1950 (December, 1939). 19 pp., illus. 6 references. British Information Services, New York. $1.00.

Fuels & Lubricants (12)

Aviation Turbine Fuel—What an Engine Manufacturer Would Like. E. A. Droegemueller. *Esso Air World*, Vol. 3, No. 3, November-December, 1950, pp. 64–69, illus.

Fuel characteristics for optimum engine performance. These specifications were determined from a study by Pratt & Whitney Aircraft of aircraft and engine requirements and the needs of the operator from the standpoint of the range of fuel types available.

Synthesis of Cyclopropane Hydrocarbons from Methyl-Cyclopropyl Ketone. I—2-Cyclopropylpropene and 2-Cyclopropylpropane. II—2-Cyclopropyl-1-Pentene, Cis and Trans 2-Cyclopropyl-2-Pentene, and 2-Cyclopropylpentane. Vernon A. Slabey and P. H. Wise. *U.S., N.A.C.A., Technical Notes Nos. 2258, 2259*, January, 1951. 17, 20 pp.; illus. 12, 4 references.

Synthesis and Purification of Some Alkylbiphenyls and Alkylbicyclohexyls. Irving A. Goodman and Paul H. Wise. *U.S., N.A.C.A., Technical Note No. 2260*, January, 1951. 29 pp., illus. 23 references.

Evaluating Rocket Propellant Performance. Joseph Himpan. *Interavia*, Vol. 5, No. 10, October, 1950, pp. 530–532, illus.

A simple formula is developed for the evaluation of the performance of a rocket propellant. It is shown that rocket-propellant performance depends on exhaust velocity, specific gravity of the propellant, and the rocket design index. Characteristics of the most likely rocket propellants are tabulated.

Rocket Propellants. Heinz Gartmann. *Interavia*, Vol. 5, No. 10, October, 1950, pp. 527–529, illus. 1 reference. Operational aspects of the most likely rocket propellants.

Structure of Thin Films of Aliphatic Esters and Alcohols on Metals. J. V. Sanders and D. Tabor. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 204, No. 1079, January 9, 1951, pp. 525–533, illus. 18 references.

Orientation of Fatty Acid and Soap Films on Metal Surfaces. J. W. Menter and D. Tabor. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 204, No. 1079, January 9, 1951, pp. 514–524. illus. 33 references.

The McKee Worker-Consistometer with Constant-Speed Drives. Samuel A. McKee and Hobart S. White. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 1, January, 1951, pp. 18–29, illus. 2 references. (Also available as *Research Paper No. 2170*. U.S. Govt. Printing Office, Washington. $0.10.)

Gliders (35)

A New British High-Performance Sailplane, the Slingsby 34A. J. C. Reussner. *Aeronautics*, Vol. 23, No. 6, January, 1951, pp. 44–47, illus.

Guided Missiles (1)

Some Statistical Considerations of the Jet Alignment of Rocket-Powered Vehicles. A. L. Stanly. *American Rocket Society, Journal*, No. 83, December, 1950, pp. 155–168, illus.

An analysis of misalignment shows that it arises from mechanical and gaseous misalignments stemming from nonaxial and nonsymmetric manufacture. Adding the specific tolerances of individual sources of mechanical misalignment according to r.m.s. sums results in numerous small tolerances having a negligible effect while a few large tolerances have a relatively predominant

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effect. Controlling alignments for groups of parts, rather than for individual parts, reduces overall misalignments.

Rockets Today; the Military Potentialities of Jet Propulsion. James R. Randolph. *Ordnance*, Vol. 35, No. 184, January-February, 1951, pp. 300, 301, illus. Rockets and ram-jets.

Viking Flights Prove Research Worth. *Aviation Week*, Vol. 54, No. 3, January 15, 1951, pp. 24–26, 28, illus. 1 reference.

The Viking rockets, built by The Glenn L. Martin Co., have completed six successful launchings. The rocket and its related ground installations are described; development is summarized chronologically.

Hypervelocity Missiles. L. G. Pooler. *Ordnance*, Vol. 35, No. 184, January-February, 1951, pp. 295–297, illus. Outline of hyperballistics studies (Mach range = 5–10) on the behavior of projectiles, missiles, and guns; research facilities and tools.

Instruments (9)

A Survey of Stability Analysis Techniques for Automatically Controlled Aircraft. Arthur L. Jones and Benjamin R. Briggs. *U.S., N.A.C.A., Technical Note No. 2275*, January, 1951. 112 pp., illus. 53 references.

A survey and evaluation of stability analysis techniques that are commonly applied to linear continuous control systems in which the difference between input and output quantities is measured continuously and is used in the operation of a closed-loop system. The calculations are carried out for a typical high-speed fighter aircraft having an automatic pilot.

Wind-Tunnel Investigation of a Number of Total-Pressure Tubes at High Angles of Attack; Supersonic Speeds. William Gracey, Donald E. Coletti, and Walter R. Russell. *U.S., N.A.C.A., Technical Note No. 2261*, January, 1951. 48 pp., illus. 2 references.

A wind-tunnel investigation was conducted to determine the effect of inclination of the air stream on the measured pressures of 20 total-pressure tubes through an angle of attack of −15° to 45° at Mach Numbers 1.62, 1.94, and 2.40. Results obtained with these same tubes at subsonic speeds have been previously reported in *N.A.C.A. RM L50G19*.

The Effect of Compressibility on Static Heads. C. N. H. Lock, A. E. Knowler, and H. H. Pearcey. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2386*, 1950 (January, 1943). 13 pp., illus. 6 references. British Information Services, New York. $0.75.

Three different types of model static heads 0.292 in. in diameter were tested in the N.P.L. 1-ft. circular high-speed tunnel at Mach Numbers up to 0.87 to determine the best type of static head for reliable air-speed readings in dives at speeds up to Mach 0.8.

A Note on the Calibration and Use of a Shielded Hot-Wire Anemometer for Very Low Speeds. C. F. Cowdry. *Journal of Scientific Instruments*, Vol. 27, No. 12, December, 1950, pp. 327–329, illus. 2 references.

A method for calibrating low-speed hot-wire anemometers by the use of a small whirling arm. Nominal wind speed range for the tests was 0–7.0 ft. per sec. Results show errors introduced when the anemometer is inclined to the wind direction.

Presentation of Information by Aircraft Instruments: Experimental Enquiries. I—Size Comparison of Two Patterns of Air Speed Indicator. J. Spencer. *Gt. Brit., Royal Air Force, Flying Personnel Research Committee, Report No. 735*, June, 1950. 18 pp., illus. 4 references. Experiments to determine the effects on reading accuracy of decreasing the diameter of the air-speed indicator by $^1/_2$ in.

Comparative Evaluation of Pictorial and Symbolic VOR Navigation Displays in the 1-CA-1 Link Trainer. S. N. Roscoe, J. F. Smith, B. E. Johnson, P. E. Dittman, and A. C. Williams, Jr. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 92*, October, 1950. 123 pp., illus. 6 references.

Results of experiments on the performance of private and instrument pilots using a symbolic and pictorial VOR display to solve common local navigation problems in a 1-CA-1 Link Trainer. The pictorial type was superior to the symbolic type. Test results do not predict the frequency of errors or their probable size in using either type in the air; use of the pictorial system will result in fewer errors.

Investigation of Perceptual Factors Involved in the Interception of PPI Scope Presentations: Literature and Introduction. Siegfried J. Gerathewohl. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-24-9, Report No. 1*, September, 1950. 17 pp., illus. 41 references.

Follow Oil Pressures with Electrons. Ben Main. *Applied Hydraulics*, Vol. 4, No. 1, January, 1951, pp. 13–15, illus.

An electronic gage for checking hydraulic pressure. A Wheatstone bridge provides an electrical output that is proportional to the pressure applied to the pickup; a cathode-ray tube displays rapid pressure changes. Pressure may be plotted against time, movement, or temperature.

Radiation Hazards in Large Scale Storage of Luminous Instruments. Hermann J. Schaefer. *Contact*, Vol. 9, No. 1, January, 1951, pp. 20–27, illus. 1 reference.

Laws & Regulations (44)

Airspace Rights over the Arctic. John C. Cooper. *Air Affairs*, Vol. 3, No. 3, December, 1950, pp. 517–540.

Machine Elements (14)

GEARS & CAMS

The Efficiency of Planetary Gear Trains. R. Poppinga. (*Glasers Annalen*, Vol. 74, No. 8, August, 1950, pp. 139–145.) *The Engineer's Digest*, Vol. 11, No. 12, December, 1950, pp. 421–425, illus.

A method of calculating the efficiency of planetary gear trains is demonstrated by means of 17 examples from practice. The efficiencies of the various gear trains differ considerably and vary greatly with the gear ratio.

Operational Stresses in Automotive Gears. Earle Buckingham. *SAE Quarterly Transactions*, Vol. 5, No. 1, January, 1951, pp. 43–55, illus. 3 references.

Combined stresses in gears are analyzed by a photoelastic method in which a replica of the part (made of transparent material) is examined with polarized light as it is being stressed. The visual stress pattern can then be evaluated. Formulas and stress patterns are given for the different types of stresses found in gear teeth under loads. The influence of plasticity and repeated stressing on the strength of the material is examined.

Designing Spur and Helical Gears for Durability. Harold M. Durham. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 149–152, illus. 1 reference. A simplified method for calculating gears for wear or durability; charts supply the necessary calculation factors.

SHAFTS & ROTATING DISCS

Designing Taper Involute Splines. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 117–121, illus. 1 reference.

SPRINGS

Prestressed Springs. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 141, 142, illus.

Applications of the Neg'ator, made by Hunter Spring Co., as an extension spring, an auxiliary clamping device, or a spring motor capable of storing and delivering rotational energy.

Materials (8)

METALS & ALLOYS

A Structural-Efficiency Evaluation of Titanium at Normal and Elevated Temperatures. George J. Heimerl and Paul F. Barrett. *U.S., N.A.C.A., Technical Note No. 2269*, January, 1951. 16 pp., illus. 14 references.

Evaluation of titanium under compressive loading without buckling, in column buckling, and the buckling of long plates in compression and shear at temperatures of 80°, 400°, and 600°F.

The Resistance of Aluminum and Beryllium Bronzes to Fatigue and Corrosion-Fatigue. D. G. Sopwith. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2486*, 1950 (April 18, 1940). 9 pp., illus. 3 references. British Information Services, New York. $0.50.

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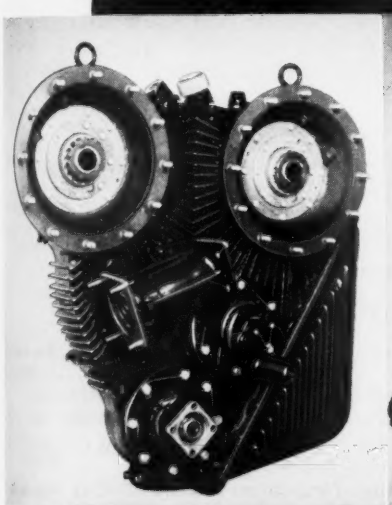

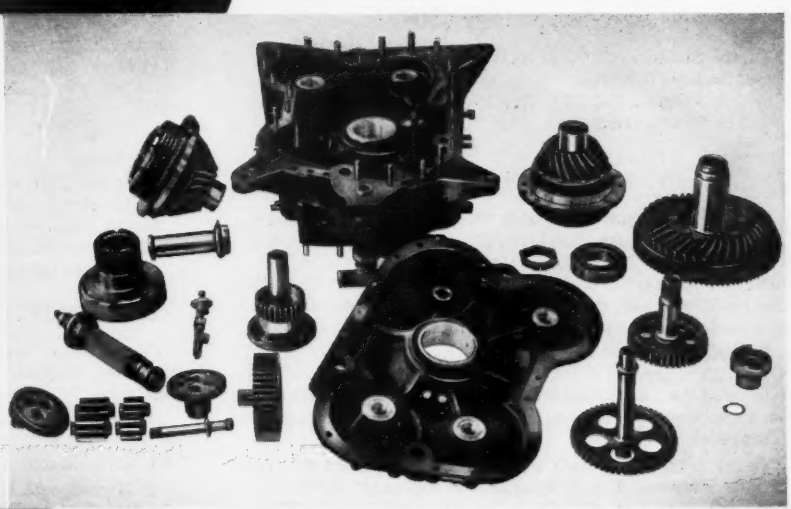

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Results of Recent Tests on Resistance to Weld Decay of Low-Carbon Stainless Steels. I. G. R. Bolsover. *Sheet Metal Industries*, Vol. 28, No. 285, January, 1951, pp. 73–76, illus.

Welded specimens of 18/8 stainless steel with a 0.03 per cent maximum carbon content were tested for resistance to weld decay. Results were compared with those of tests on steel of somewhat higher carbon content which had been treated with titanium.

Measurement of Surface Wear. H. Meincke. (*Metalloberfläche*, Vol. 4, No. 10, October, 1950, pp. 145–151.) *The Engineer's Digest*, Vol. 11, No. 12, December, 1950, pp. 417–419, illus. An investigation to establish standard criteria of abrasion measurement in surface-hardness testing.

Corrosion Fatigue; the Influence of Disarrayed Metal. D. Whitwham and U. R. Evans. *Corrosion*, Vol. 7, No. 1, January, 1951, pp. 28–40, illus. 5 references.

NONMETALLIC MATERIALS

Some Notes on the Manufacture of Modern Airplane Hoods. Erik Åhman. *Saab Sonics*, No. 12, October–December, 1950, pp. 6–10, illus. Acrylic glass for airplane hoods: special properties and molding methods.

PROTECTIVE COATINGS

Surface Treatment and Finishing of Light Metals. V. S. Wernick and R. Pinner. *Sheet Metal Industries*, Vol. 28, No. 285, January, 1951, pp. 79–87, illus. 33 references. Theory and applications of the industrial anodizing processes to aluminum; mechanism of anodic oxide film and the theory of anodic oxidation.

Meteorology (30)

On the Stability of a Fluid Heated from Below. O. G. Sutton. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 204, No. 1078, December 22, 1950, pp. 297–309, illus. 13 references.

Navigation (29)

Periscope Sextant Eliminates Dome. *Product Engineering*, Vol. 22, No. 1, January, 1951, pp. 114, 115, illus.

The Periscopic Sextant, developed by the Kollsman Instrument Div., Square D Co., takes readings through a 3.8-in. tube that projects $1^1/_2$ in. into the slipstream. The instrument can be used as an astrocompass or to take bearings.

Navigation Without Tears. J. C. Neilan. *The Aeroplane*, Vol. 80, No. 2059, January 5, 1951, pp. 11, 12, illus. Operation and reliability of the Decca Flight Log, a radio-fixing system that gives the pilot instantaneous, continuous, and permanent navigational information and records.

Visual Aids to Approach and Landing; Appendix to Article "Pilot's Responsibility in Aviation Development" by J. Woodman. *The Log*, Vol. 11, No. 1, January, 1951, pp. 13–20, illus. Pilot's reaction to various landing-light configurations; the perspective geometry of the configurations.

Final Report on Evaluation of Omni-Bearing-Distance System of Air Navigation. W. R. Rambo, J. S. Prichard, D. P. Duffy, R. C. Wheeler, A. E. Dusseau, Jr., and S. Goldstein. *Airborne Instruments Laboratory, Inc., Report No. 540-2*, October, 1950. 2 Vols., 186, 158 pp.; illus. 26, 47 references.

International Navigation-Aids. C. B. Bailey-Watson. *Flight*, Vol. 59, No. 2190, January 11, 1951, pp. 44–47, illus. Comparison of U.S. and British navigation systems; evaluation of the Decca Navigator system.

Comparative Evaluation of Pictorial and Symbolic VOR Navigation Displays in the 1-CA-1 Link Trainer. S. N. Roscoe, J. F. Smith, B. E. Johnson, P. E. Dittman, and A. C. Williams, Jr. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 92*, October, 1950. 123 pp., illus. 6 references.

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Ordnance & Armament (22)

Fighter Armament. VI—Gun Design and Installation. A. R. Weyl. *Flight*, Vol. 59, No. 2189, January 4, 1951, pp. 6–8, illus. Muzzle velocity and rate of fire; methods of use; weight and bulk.

Parachutes

Drag Characteristics of Parachutes. S. F. Hoerner. *U.S., Air Force, Technical Report No. 6201*, October, 1950. 15 pp., illus. 17 references.

The drag of pervious sheets is investigated as a function of the permeability. The drag of parachute-like bodies in a stationary position is evaluated from experiments. The aerodynamic forces and mechanics of freely gliding parachutes are derived.

Photography (26)

Saab Photography. John A. Sandh. *Saab Sonics*, No. 12, October–December, 1950, pp. 11, 14, illus. Industrial photography use and methods at the Saab Works, Sweden.

Versatility Feature of New Camera. *Aviation Week*, Vol. 54, No. 3, January 15, 1951, pp. 48, 49, illus.

The Model IV 35-mm. synchronous motion-picture camera, developed by Flight Research Engineering Co., is capable of maintaining one-millisecond shutter accuracy. Designed primarily for flight testing and missile tracking, it can take either single-frame or continuous exposures. Other applications include oscillograph photography.

Discussion on "The Flash Tube and Its Applications" by J. N. Aldington and A. J. Meadowcroft. *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 97, No. 55, February, 1950, pp. 87–91.

Power Plants

An Interesting Flow-Valve. *The Aeroplane*, Vol. 80, No. 2059, January 5, 1951, p. 27, illus.

A continuous flow-valve suited to aircraft fuel and hydraulic systems. The valve, developed by Tiltman Langley Laboratories, Ltd., can be remotely controlled electrically, hydraulically, pneumatically, or mechanically.

JET & TURBINE (5)

Regenerator-Design Study and Its Applications to Turbine Propeller Engines. S. V. Manson. *U.S., N.A.C.A., Technical Note No. 2254*, January, 1951. 52 pp., illus. 8 references.

Practical Aspects of Turbojets in Transport Aircraft. R. T. Holland and E. L. Auyer. *Aeronautical Engineering Review*, Vol. 10, No. 3, March, 1951, pp. 32–35, illus.

A High-Speed, High-Temperature Precision Testing Machine for Gas Turbine Disk Research. A. C. Hagg, B. Cametti, and G. O. Sankey. *Westinghouse Electric Corp., Westinghouse Research Laboratories, Scientific Paper No. 1461*, August 19, 1949. 29 pp., illus. 3 references.

The equipment was developed primarily to measure accurately and control the test parameters of speed (stress) and temperature and to determine plastic and creep strain occurring under the controlled test conditions. Data obtained indicate that the machine is reliable in its operation.

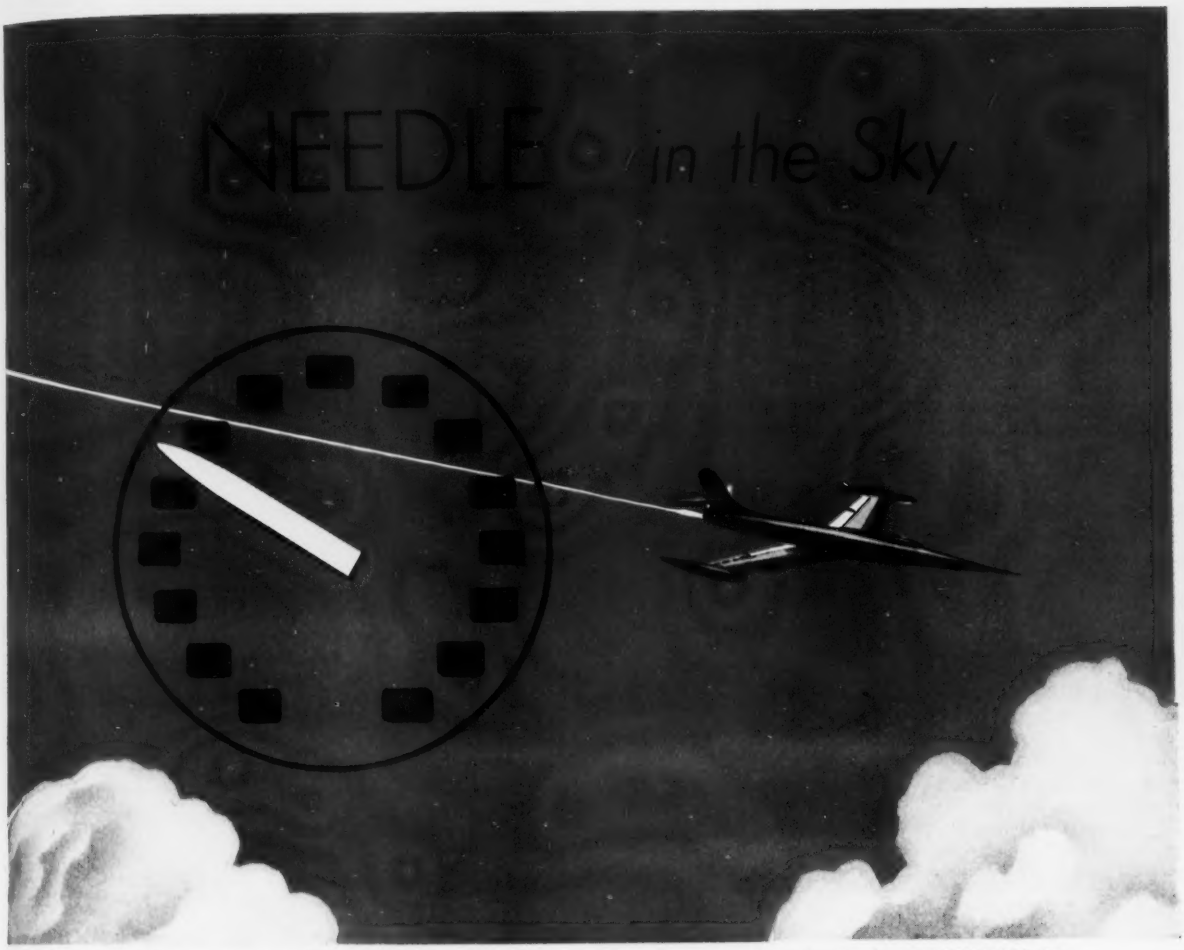
Turbine-Engine Anti-Icing Tested Atop Mt. Washington. P. M. Bartlett and T. A. Dickey. *SAE Journal*, Vol. 59, No. 1, January, 1951, pp. 25–28, illus. (Excerpts from a paper.)

Cartridge Turbo-Starters for Aeronautical Gas Turbines. *The Engineer*, Vol. 190, No. 4952, December 22, 1950, pp. 635, 636, illus. Cartridge turbostarter developed by Rotax, Ltd., and the Plessey Co., Ltd.

G-E Turbojet Progress. Paul H. Wilkinson. *Aviation Age*, Vol. 15, No. 1, January, 1951, pp. 32, 33, illus.

A Russo-German Turbojet—the M-012. *Interavia*, Vol. 5, No. 11, November, 1950, pp. 586–588, illus.

A development of the Jumo 004. It gives a static thrust of 4,000 lbs. at 9,000 r.p.m., is 177 in. in length with a diameter of 43 in., and has an eleven-stage axial compressor and a two-stage turbine.



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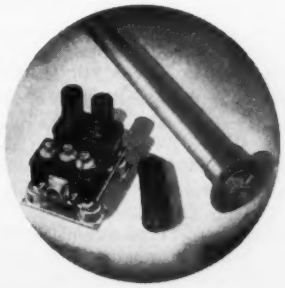

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RECIPROCATING (6)

Elimination of Combustion Knock—Texaco Combustion Process. E. M. Barber, Blake Reynolds, and W. T. Tierney. *SAE Quarterly Transactions*, Vol. 5, No. 1, January, 1951, pp. 26–38, Discussion, pp. 38–43, illus. 11 references.

The Texaco Combustion Process (TCP) is a method for operating the combustion phase of the cycle of a reciprocating internal-combustion engine so that knock does not occur, regardless of the octane rating of the fuel or of the compression ratio or supercharge of the engine. TCP is relatively insensitive to fuel volatility. The theory, physical apparatus, efficiency, and typical characteristics of the TCP engine are explained. TCP results in approximately a 30 per cent fuel saving.

Further Study of Metal Transfer Between Sliding Surfaces. J. T. Burwell and C. D. Strang. *U.S., N.A.C.A., Technical Note No. 2271*, January, 1951. 39 pp., illus. 14 references.

Tests were carried out to determine the effect of the transfer of metal from one rubbing surface to another on the formation of surface coatings on piston-ring materials during run-in of an aircraft engine. One of the rubbing surfaces was made radioactive, the friction test was applied, and the other surface was examined for radioactivity. Test materials were nitralloy steels (nitrided and unnitrided) and several chromium-plated surfaces.

Resistor-Suppressors Found to Have No Effect on Starting Cold Engines. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 1, January, 1951, pp. 11, 12, illus.

ROCKET (4)

Rocket-Engine Flight Testing. Richard F. Gompertz. *American Rocket Society, Journal*, No. 83, December, 1950, pp. 169–176, illus. Outline of a rocket-engine flight-test program set up at an Air Force experimental flight-test base.

Designing a JATO Engine. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 102–106, illus.

Design development of the basic rocket-engine components, considering in detail the propellant cartridge, chamber assembly, nozzle throat, and the program of obtaining ignition reproducibility.

Production (36)

Experimental Gas-Turbines; Some Problems of Small-Quantity Manufacture. L. H. Leedham. *Aircraft Production*, Vol. 13, No. 147, January, 1951, pp. 27–31, illus. (Abstract of a paper.)

Blade-Machining. *Aircraft Production*, Vol. 13, No. 147, January, 1951, pp. 8, 9, illus.

The Tracermatic 14-station machine used for the multiple copy-milling of gas-turbine blades embodies the principle of single-point copying and the means for multiple-machining in one unit. It was developed by Modern Tool Works, Ltd. of Toronto for use by A. V. Roe Canada Ltd.

How Aircraft Design Changes Can Be Controlled. E. F. Stoner. *Automotive Industries*, Vol. 104, No. 1, January, 1951, pp. 38, 39, 90, 92, 94, 96, illus.

Procedures of the Change Control Dept. of Douglas Aircraft Co. in arranging for the incorporation of design changes into production of aircraft in the most effective and economical manner.

Aircraft Industry Must Outdo World War II Achievements. Robert McLarren. *Automotive Industries*, Vol. 104, No. 2, January 15, 1951, pp. 38–40, 120, 122, 124, illus. Problems facing the aircraft industry in attempting to meet defense requirements.

Production Development (Lockheed) of a Jettisonable Fuel Tank. A. H. Petersen. *Automotive Industries*, Vol. 104, No. 2, January 15, 1951, pp. 44, 108, 110, 112, illus.

Some Notes on the Manufacture of Modern Airplane Hoods. Erik Åhman. *Saab Sonics*, No. 12, October–December, 1950, pp. 6–10, illus. Acrylic glass for airplane hoods: special properties and molding methods.

Subassembly Riveting. *Aircraft Production*, Vol. 13, No. 147, January, 1951, pp. 12–17, illus.

Application of the Erco automatic riveting machine to the assembling of air-frame units at Consolidated Vultee Aircraft Corp., de Havilland Aircraft Co., Ltd., and Percival Aircraft, Ltd. The machine, built by Engineering and Research Corp., Riverdale, Md., handles the entire riveting sequence of punching, dimpling, inserting, and heading of the rivet in two operations of the anvil.

Spin-Dimpling; Cold Process (Bristol Aeroplane Co., Ltd.) for Producing a Close-Tolerance Countersunk Form for Flush Riveting. *Aircraft Production*, Vol. 13, No. 147, January, 1951, pp. 3–7, illus.

Tools for the Job. *The Aeroplane*, Vol. 80, No. 2059, January 5, 1951, pp. 13–17, illus. Spin-dimpling and squeeze-riveting automatic production processes (Bristols and Ratcliffe).

Machining of Heated Metals. E. T. Armstrong, A. S. Cosler, Jr., and E. F. Katz. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 35–43, illus. 9 references.

The Effect of the Cutting Fluid upon Chip-Tool Interface Temperature. M. C. Shaw, J. D. Pigott, and L. P. Richardson. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 45–52, Discussion, pp. 52–56, illus. 11 references.

An Analytical Evaluation of Metal-Cutting Temperatures. K. J. Trigger and B. T. Chao. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 57–66, Discussion, pp. 66–68, illus. 28 references.

Residual Stresses in Machined Surfaces. E. K. Henriksen. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 69–76, illus. 18 references.

Experience with Machinability Repeat-Ability. E. J. R. Hudec. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 17–20, illus.

Experiments to establish tool-life values brought up the problem of making accurate repeat runs with machine tools. The difficulties encountered are listed, and a procedure is suggested for obtaining high machinability repeatability.

A Study of Heat Developed in Cylindrical Grinding. R. E. McKee, R. S. Moore, and O. W. Boston. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 1, January, 1951, pp. 21–34, illus. 3 references.

A Survey of Modern Theory on Welding and Weldability. II. D. Séférian. *Sheet Metal Industries*, Vol. 28, No. 285, January, 1951, pp. 59–72, 76, illus.

The influence of the alloy constituents on the welding of chromium-molybdenum steels, low-alloy copper-chromium steels, plain chromium steels, and austenitic nickel-chromium stainless steels of the 18/8 type; welding processes for each type of steel.

Propellers (11)

Splined Positive Lock. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 115, 116, illus. Design of a positive lock with extremely fine adjustment for holding propeller blades against change of angle.

Aeroproducts Division, General Motors Corporation, Spin Pit for Supersonic Propellers. *Shell Aviation News*, No. 150, December, 1950, p. 20, illus.

Rotating Wing Aircraft (34)

Readers' Forum: Comments on "A Type of Lifting Rotor with Inherent Stability." G. J. Sissingh. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 210, 211, illus.

The Helicopter. I—First Principles and a Brief History; Rotating Systems and Their Controls. II—Power and Lift; Flight Control and Its Relation to Hub Design. N. R. Liptrot. *Flight*, Vol. 59, Nos. 2189, 2190, January 4, 11, 1951, pp. 17–20; 48–51; illus., cutaway drawings.

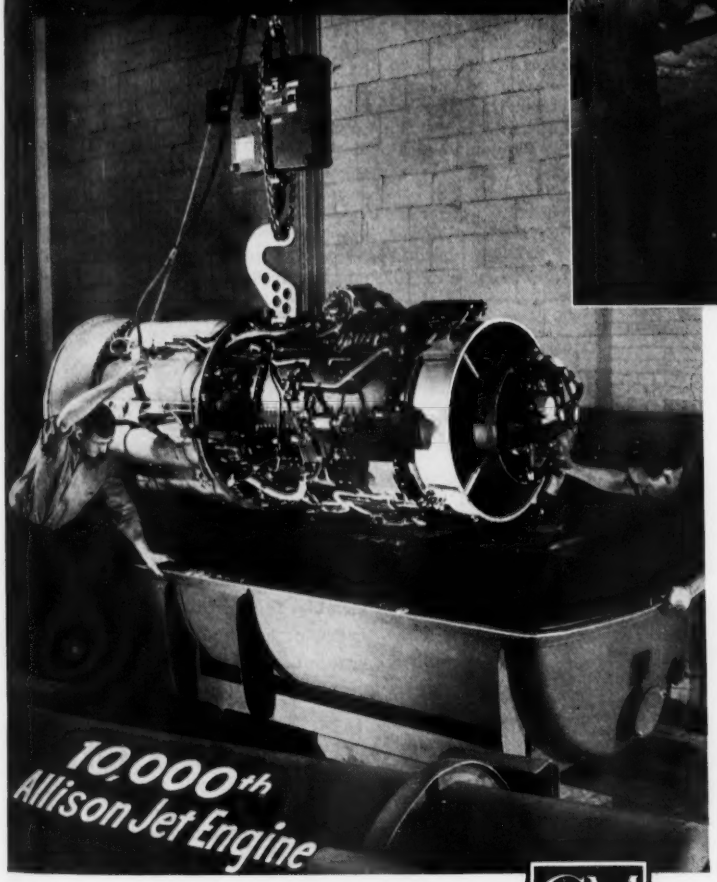
USAF Copter Instrument Course. *Aviation Week*, Vol. 54, No. 4, January 22, 1951, pp. 27, 28.

Instrument Phase for USAF Helicopter Pilot Course. *American Helicopter*, Vol. 21, No. 1, December, 1950, pp. 6–8, 20, 21.

The Rotary Wing Pictorial Review for 1950. *American Helicopter*, Vol. 21, No. 1, December, 1950, pp. 9–19, illus. Photographs and specifications of 42 helicopters.

Helicopter Maintenance. David H. Kaplan. *Aviation Age*, Vol. 15, No. 1, January, 1951, pp. 26, 27, illus. Maintenance of the helicopter tail rotor; transmission and control problems.

Allison delivers its 10,000th Jet Engine



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Sciences, General (33)

MATHEMATICS

Notes on the Linearized Equation for the Velocity Potential of the Steady Supersonic Flow of a Compressible Fluid. R. K. Tempest and L. Rosenhead. **Note.** W. N. Bailey. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 3, March 20, 1947, March 17, 1949, pp. 197–212; 213, 214. 11, 2 references.

Review of the physical background for the linearized differential equation of the velocity potential of a compressible fluid in steady supersonic flow. The applications of known solutions of the wave equation are given physical interpretations in supersonic flow. Two new solutions appropriate to systems of conical and wedge coordinates are derived.

Practical Solution of Simultaneous Linear Equations. O. L. Bowie. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 369–373. 3 references.

The "rounding off" of errors in the solution of a set of simultaneous linear equations with constant coefficients is studied to determine techniques for increasing the accuracy of solution through the use of ordinary computational procedures.

Formulas for Numerical Integration of First and Second Order Differential Equations in the Complex Plane. Herbert E. Salzer. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 207–216.

Routine Computing Methods for Stability and Response Investigations on Linear Systems. H. R. Hopkin. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2392*, 1950 (August, 1946). 50 pp., illus. 32 references. British Information Services, New York. $2.00.

Computing methods for the solution of linear differential equations with constant coefficients. General methods are given for the solution of polynomial equations, for finding real and complex roots, and for obtaining two types of stability diagrams.

A New Form of Solution of Hermite's Equation. W. A. Mersman. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 191–197. 4 references.

A study of a modified form of Hermite's equation which occurs in the study of the laminar boundary layer of a compressible fluid over a heated flat plate to obtain a solution that is tractable to numerical methods of computation. The method is applicable to any linear homogeneous differential equation of the second order to obtain a second solution when one is already known.

A Criterion for the Absolute Convergence of a Fourier Series. R. Mohanty. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 3, March 20, 1947, pp. 186–196. 9 references.

Transformations to Speed the Convergence of Series. J. Barkley Rosser. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 1, January, 1951, pp. 56–64, illus. 12 references. (Also available as *Research Paper No. 2175*. U.S. Govt. Printing Office, Washington. $0.10.)

Fourier-Stieltjes Integrals. J. L. B. Cooper. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 4, June 19, 1947, pp. 265–284. 6 references.

Discussion of functions of Class E, which are defined as: $f(x)$ is a member of the Class E if $f(x)e^{-\epsilon|x|}$ is $L(-\infty, \infty)$ for all $\epsilon > 0$. Necessary conditions are given for functions of the Class E to be represented by Fourier-Stieltjes integrals. The summability of such integrals is developed.

New Matrix Transformation for Obtaining Characteristic Vectors. William Feller and George E. Forsythe. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 325–331. 16 references.

Formulas are given for a four-parameter family of transformations; the family is general enough to include deflation and the procedures of Duncan and Collar, Semendiaev, and Blanch as special cases. Two subclasses of the transformation, order-reducing and symmetry-preserving, are discussed. This family of transformations appears practical for work with symmetric matrices and may be of value for nonsymmetric matrices.

Random Walks and the Eigenvalues of Elliptic Difference Equations. Wolfgang Wasow. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 1, January, 1951, pp. 65–73. 7 references. (Also available as *Research Paper No. 2176*. U.S. Govt. Printing Office, Washington. $0.10.)

Explanation of a random-walk procedure that can be used to approximate the solutions of elliptic partial differential equations

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that contain the unknown function as well as its derivatives. The process also permits the numerical determination of the lowest eigenvalue for such an equation.

On Expansions in Eigenfunctions, Particularly Bessel Functions. T. M. Cherry. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 1, December 16, 1943, pp. 14–45. 5 references.

Inequalities in the Theory of Functions. W. K. Hayman. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 6, November 14, 1946, pp. 450–473, illus. 5 references.

On Functional Transformation and Summability. A. Robinson. *London Mathematical Society, Proceedings*, Vol. 52 (Series 2), Part 2, October 16, 1947, pp. 132–160. 4 references. A generalization of the concept of summability.

Mean Value Theorems in Recursive Function Theory. I—Differential Mean Value Theorems. R. L. Goodstein. *London Mathematical Society, Proceedings*, Vol. 52 (Series 2), Part 2, November 15, 1945, pp. 81–106. 6 references.

Numerical Quadrature of Analytic and Harmonic Functions. Garrett Birkhoff and David Young. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 217–221. 5 references. Discussion of the five-point formula for numerical quadrature of real harmonic and complex analytic functions.

An Empirical Investigation of the Analysis of Variance Method When the Underlying Assumptions Are Not Fulfilled; On the Distribution of Some Statistics in Regression Analysis When Observations Are Not Independent. Max Halperin. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-49-003, Report No. 4*, October, 1950. 19 pp. 3 references.

Best Interpolation Formulas. Leroy F. Meyers and Arthur Sard. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 198–206. 3 references.

Checking and Interpolation of Functions Tabulated at Certain Irregular Logarithmic Intervals. Herbert E. Salzer. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 1, January, 1951, pp. 74–77. 5 references. (Also available as *Research Paper No. 2177*. U.S. Govt. Printing Office, Washington. $0.10.)

Tables for checking the accuracy of $f(x)$ when tabulated at 1, 2, 5, . . ., or some of the combinations of these values. The tables simplify Lagrangian interpolation by use of a method given by W. H. Taylor.

Space Travel

Earth Satellite Vehicles. R. Engel. *Interavia*, Vol. 5, No. 10, October, 1950, pp. 500–502, illus. 2 references. Examination of the physical and technical aspects of earth-satellite stations; estimations of the costs involved in the construction of an extra-terrestrial base.

The Shape of Ships to Come. Willy Ley. *Interavia*, Vol. 5, No. 10, October, 1950, pp. 496–499, illus. General plan form of a spaceship; suggested propulsive mechanisms; differences between equipment on the ship for a lunar run and for a trip to Mars or Venus; crew oxygen requirements.

The Interplanetary Ocean. Werner Schaub. *Interavia*, Vol. 5, No. 10, October, 1950, pp. 533–536, illus. Mathematical and physical significance of the space between the earth and the sun based on energy considerations; trajectories (leaving the earth) for maximum range.

Structures (7)

Determination of Plate Compressive Strengths at Elevated Temperatures. George J. Heimerl and William M. Roberts. *U.S., N.A.C.A., Report No. 960*, 1950. 6 pp., illus. 7 references. U.S. Govt. Printing Office, Washington. $0.10.

Tests on H-section plate assemblies of 75S-T6 aluminum alloy at temperatures up to 600°F. Results indicate that the compressive stress-strain curve for the material may be used to determine the critical compressive stress at elevated temperatures.

Plastic Buckling of a Rectangular Plate Under Edge Thrusts. G. H. Handelman and W. Prager. *U.S., N.A.C.A., Report No. 946*, 1949. 28 pp., illus. 16 references. U.S. Govt. Printing Office, Washington. $0.25.

Development of a theory of the plastic buckling of plates which agrees with the modern theory of plasticity. An analysis of the

stress-strain relations in the plastic range shows that a theory of plastic flow is indicated rather than a theory of plastic deformation for buckling phenomena. The fundamental equation of the plastic buckling of a simply compressed plate is developed, and an equivalent energy principle is given for making approximate computations.

Readers' Forum: Buckling of a Pretwisted Pin-Ended Column. G. V. R. Rao. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 211, 212, illus. 2 references.

Inelastic Column Behavior. John E. Duberg and Thomas W. Wilder, III. (*Journal of the Aeronautical Sciences*, Vol. 17, No. 6, pp. 323–327.) *U.S., N.A.C.A., Technical Note No. 2267*, January, 1951. 44 pp., illus. 7 references. Analytical details additional to those given in the paper as first published.

Interaction Curves for the Critical Loads on Continuous Beam-Columns. Earl Rottmayer. *Aeronautical Engineering Review*, Vol. 10, No. 3, March, 1951, pp. 40–42, illus. 1 reference.

Plastic Design of Beams and Plane Frames for Minimum Material Consumption. Jacques Heyman. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 373–381, illus. 1 reference.

Linear inequalities are set up for the variables involved in the design of plane frames for minimum material consumptions and are solved by the Dines' method. The frame considered consists of straight members in the same plane.

Graphical Analysis of Axially End-Loaded Beams. H. D. Conway. *Machine Design*, Vol. 23, No. 1, January, 1951, pp. 137–140, 188, illus. 3 references.

The variation of bending moment in a member subjected simultaneously to longitudinal compression and lateral loading can be obtained by a graphic solution of the differential equation for the elastic curve of the member.

Load Distribution and Relative Stiffness Parameters for a Reinforced Circular Cylinder Containing a Rectangular Cut-Out. L. S. D. Morley and W. K. G. Floor. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. S.362* (*Verslagen en Verhandelingen*, Vol. 15, pp. S47–S68), 1949. 22 pp., illus. 9 references.

A method that is exact within the limits of conventional shell theory is given for the determination of the load distribution and relative stiffness parameters of a reinforced circular cylinder that has three bays with a rectangular cutout in the center bay and that is undergoing torsion, bending, shear, and tension.

Stresses in a Stiffened Circular Cylinder Under Concentrated Axial Loads. D. C. Allen. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2405*, 1950 (January, 1946). 10 pp., illus. 3 references. British Information Services, New York. $0.50. Solutions in the form of infinite series are obtained for the stress distribution in a long circular cylindrical shell under axial loads at four longerons in tension and bending action.

Some General Solutions of St. Venant's Torsion and Flexure Problem. III. Rosa M. Morris. *London Mathematical Society, Proceedings*, Vol. 51 (Series 2), Part 6, November 14, 1946, pp. 424–439. 8 references.

The solutions derived by Love for the hollow shaft bounded by a confocal ellipse and Seth's solution for a circular cylinder with an eccentric circular cylindrical hollow are extended to the general case of a hollow cylinder having a cross section that is the space between any two level surfaces. The method applies to transformation of both the internal and external types. A solution is derived for the flexure problem of the hollow cylinder. The transformation and essential results are given for a cylinder in which the inner and outer boundaries are cardioids and for a cylinder for which the fundamental curve is a circular arc of small camber.

A General Survey of the Effects of Flexibility of the Fuselage, Tail Unit and Control Systems on Longitudinal Stability and Control. H. M. Lyon and J. Ripley. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2415*, 1950 (July, 1945). 69 pp., illus. 20 references. British Information Services, New York. $2.85.

Note: A Minimum Principle for Structural Stability. H. J. Weiss and G. H. Handelman. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp 395–401. 3 references.

The Method of Characteristics Applied to Problems of Steady Motion in Plane Plastic Stress. P. G. Hodge, Jr. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 381–386. 5 references.

Outline of a procedure for obtaining the stress, strain, and thickness distribution of a thin sheet that is strained plastically in its plane. Exact solutions are obtained for several boundary-value problems.

On the Theory of Thin Elastic Toroidal Shells. R. A. Clark. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 146–178, illus. 10 references.

The small deflection theory of thin shells of revolution loaded symmetrically with respect to their axis is used to study toroidal ring and shell problems. Solutions are found by applying methods of asymptotic integration of a differential equation involving a large parameter multiplied by a function that vanishes at certain points. Explicit formulas are given for the maximum stresses and displacements in terms of the dimensions of the shells.

Note of the Stresses Produced by Nuclei of Thermo-Elastic Strain in a Semi-Infinite Elastic Solid. Bibhutibshusan Sen. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 365–369. 2 references.

On the Method of Inversion in the Two-Dimensional Theory of Elasticity. E. Sternberg and R. A. Eubanks. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 392–395. 9 references.

Plastic Wave Propagation in a Bar of Material Exhibiting a Strain Rate Effect. L. E. Malvern. *Quarterly of Applied Mathematics*, Vol. 8, No. 4, January, 1951, pp. 405–411, illus. 9 references.

Extension of the theory of the propagation of a transient wave of plastic deformation due to longitudinal impact on a bar to apply to materials in which the stress is a function of the instantaneous plastic strain and strain rate.

Test Techniques Using Electro-Dynamic Shakers. R. C. Lewis. *Product Engineering*, Vol. 22, No. 1, January, 1951, pp. 142–147, illus. 3 references. Methods for evaluating the effects of structural changes in corrective design and for finding points of application at which resonant vibrations will produce failure in mechanical parts and assemblies.

Air Bags as Flexible Supports in Ground Resonance Testing of Aircraft. R. L. Moffat and D. R. Gaukroger. *Gt. Brit., Aeronautical Research Council, Current Papers No. 32*, 1950 (September, 1949). 14 pp., illus. 1 reference. British Information Services, New York. $0.35.

Stiffness and natural-frequency tests were made on an air bag designed for the investigation of ground resonance of medium aircraft, and results were compared with theory. Further design work is needed to obtain a bag with the desired low frequency.

Thermodynamics (18)

Experimental and Theoretical Studies of Flame-Front Stability. George H. Markstein. *Journal of the Aeronautical Sciences*, Vol. 18, No. 3, March, 1951, pp. 199–209, illus. 25 references.

Photographic experiments with rich hydrocarbon flames burning in Pyrex tubes indicated that the flames assume a cellular structure in the absence of turbulence. The effects of fuel type, mixture compositions, and pressure on this condition were studied. Theoretically it is shown that, with certain simplifying assumptions, the physiochemical properties of the combustion zone may be introduced into the hydrodynamic treatment in the form of appropriate boundary conditions at the flame front.

Method for Determining Distribution of Luminous Emitters in Cone of Laminar Bunsen Flame. Thomas P. Clark. *U.S., N.A.C.A., Technical Note No. 2246*, January, 1951. 28 pp., illus. 5 references.

The absolute distribution in the reaction zone of a flame of luminous diatomic free radicals is determined by analyzing the density distribution of the flame image on a photographic negative. The emitter concentration across the flame front is calculated from the intensity-distribution data.

Temperature Distribution in Internally Heated Walls of Heat Exchangers Composed of Noncircular Flow Passages. E. R. G. Eckert and George M. Low. *U.S., N.A.C.A., Technical Note No. 2257*, January, 1951. 39 pp., illus. 10 references.

Development of a method to calculate the temperature distribution in a heat exchanger that has noncircular flow passages and internally heated walls, assuming that the flow within the

(*Continued on page 96*)

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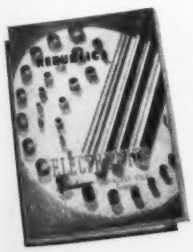

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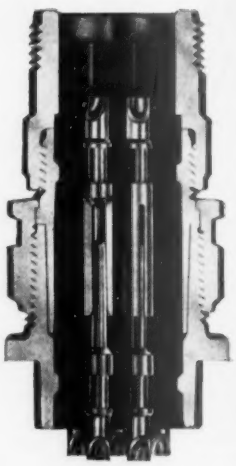

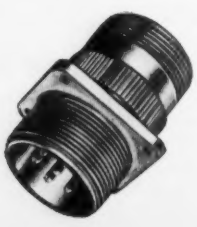

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Aeronautical Reviews — BOOKS

Book Notes

AERODYNAMICS

Aérodynamique Expérimentale. Pierre Rebuffet. 2nd Ed. Paris and Liège, Librairie Polytechnique Ch. Béranger, 1950. 795 pp., illus., diagrs. 4,400 fr.

The first edition of this excellent book was published in 1945. The original purpose has been retained—to discuss the properties of fluids, particularly air, general principles and phenomena, experimental methods, flow around geometrically simple bodies and then more complex bodies such as wings, propellers, and complete aircraft. While aeronautical applications are the author's concern, the physical aspects of aerodynamic phenomena receive emphasis throughout. In this edition all sections have been revised and considerably enlarged, and the book contains 274 more pages, 25 more plates, and 99 more figures than the 1945 edition. While the main outline is unchanged, the arrangement within most sections has been extensively revised. For example, the treatments of perfect fluids, definitions and theorems of kinematics of fluids, viscous fluids, and vortices have been incorporated into a large introductory chapter. New material in this chapter includes flow through cascades in permanent subsonic and supersonic motion, flow with normal and oblique shock waves, and flow through nozzles. M. Rebuffet is Chief of the Division Aérodynamique à l'Office National d'Études et de Recherches Aéronautiques.

AERONAUTICS, GENERAL

Association Technique Maritime et Aéronautique, Bulletin No. 49. Paris 9, The Association, 1950. 882 pp., illus., diagrs.

Contents: Le Porte-Avions en 1950, Pierre Barjot. Bâtiments de Ligne Modernes, P. Gisserot. Note sur le Temps de Remontée en Surface des Sous-Marins par Chasse au Ballast, G. de Dinechin. La Représentation Graphique des Essais d'Hélices Cavitantes, Jean Lefol. Note sur le Recul d'une Hélice Travaillant dans Différentes Conditions, G. de Dinechin. Essais en Modèle de Canal de Modèles de Navires Auto-Propulsés, R. Brard. Introduction à l'Étude de l'Aile Portante en Régime Transitoire, P. Barberon. Cas d'Équivalance entre Carènes et Distribution de Sources et de Puits, R. Brard. Problèmes Actuels d'Acoustique Aéronautique, P. Lienard. Description d'un Appareillage de Télécommande et de Télémesures pour Maquettes Volantes, M. Cambornac et F. Lajeunesse. Description d'un Appareillage de Télécommande par Radio pour Modèles de Navires, A. Simon. Application des Méthodes de la Mécanique du Mobile Dirigé à la Théorie du Vol, Plané, P. Contensou. Mesures de Stabilité des Aérodynes, L. Frager. Essais d'une Installation de Stabilisation des Navires au Roulis par Jets d'Eau, M. P. Seligmann. Détermination Rapide de l'Influence, sur le Nombre de Tours d'une Hélice, de Faibles Variations de ses Caractéristiques ou des Données de son Fonctionnement, M. Lamoureux. Les Possibilités d'Application des Matériaux Composites dans la Construction Navale, G. Fabre. Les Bois Imprégnés, G. Dixmier et A. Iablokoff. La Réflection du Paquebot Allemand Europa, J.-P. Ricard. Construction des Cargos de 3,700 T., Cambraisien et Douaisien. Préfabrication du Bordé de Carène, R. Labbens. Étude des Vibrations de Flexion et de Torsion au Moyen d'Analogies Électromécaniques. Application aux Charpentes de Navires et d'Aéronefs, G. Cahen. Tensions dans les Plaques à Tubes des Collecteurs de Chaudières, M. Ballet. Étude Expérimentale du Champ des Tensions dans une Membruer Encastrée Appuyant un Bordé Soumis à une Pression de Fluide, H. de Leiris et H. Dutilleul. Le Contrôle des Épaisseurs de Parois Métalliques, C. Brachet. Complément sur les Coques de Sous-Marine à Section Multilobée, G. de Dinechin. Note sur les Calculs de Stabilité après Avarie, dans les Conditions Prévues par la Convention de Londres 1948, R. Crenn. Lignes d'Influence Relative aux Moments Fléchissants dans les Navires, Gino Solda. La Résistance Comparative aux Vibrations de Structures Rivées et Soudées d'Echantillons d'Épaisseur Relativement Faible, H. Dutilleul et H. de Leiris. Les Mesures Extensométriques aux Lancements, M. Ballet. L'Appareil de Lignage par Projection et ses Diverses Applications, J. Legris. Quelques Remarques sur les Installations Frigo-Fret à Ammoniac ou à Fréon 12, M. Merlin. Ultra-Sons Induits et Sécurité. Une Cause Mécanique Probable des Incendies et Explosions de Navires, R. Jarry. Contribution à l'Étude de la Préfrigération, M. Merlin. Mesure des Pressions Rapidement Variables par Manomètres à Magnétostriction, P. Vincent. Application aux Navires d'un Appareil Propulsif Constitué par des Générateurs de Gaz à Pistons Libres et des Turbines à Gaz, A. Augustin-Normand Fils. Procédé Approché de Calcul de la Répartition de la Température sur les Disques et Aubes des Turbines à Gaz, D. Sochat. Remarques Diverses sur l'Ecoulement dans les Turbo-Machines à Circulation Variables, R. Legendre. Le Pompage des Compresseurs. Résultats d'Essais, R. Bidard.

FUELS & LUBRICANTS

Symposium on High Additive Content Oils. (Special Technical Publication No. 102.) Philadelphia, American Society for Testing Materials, 1949. 63 pp., illus., diagrs. $1.75.

For information on I.A.S. Library Service Facilities, see page 67

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Contents: Does Service Performance Justify Higher Quality Lubricating Oils? W. B. Bassett. High Detergency Motor Oils, A. B. Boehm and C. O. Tongberg. Five Years' Experience with Special Heavy-Duty Oils, J. A. Edgar and R. E. Jeffrey, Jr. Possible Future Military Engine Oils for Ground Equipment, N. L. Klein.

MATERIALS

Methods of Testing Vulcanized Rubber. (British Standard No. B.S. 903: 1950.) London, British Standards Institution, 1950. 247 pp. 21*s*.

This standard was first published in 1940 and is now revised for the first time. Methods of analysis are covered in the first third of the book, the greater part being devoted to physical testing, describing about 60 methods for strength, permeability, adhesion, and electric properties.

A. S. T. M. Standards on Textile Materials. Philadelphia, American Society for Testing Materials, 1950. 572 pp. $4.50.

In this edition 90 specifications, tolerances, and methods of testing are presented, including about 35 general methods and specifications and special data for asbestos, fibers, cotton, glass textiles, rayon, silk, and wool.

METEOROLOGY

The Flight of Thunderbolts. B. F. J. Schonland. London and New York, Oxford University Press, 1950. 152 pp., illus. $3.00.

Though it is written in nontechnical language and is not intended as a detailed monograph, this is the first general account of lightning and lightning protection in English. The history of concepts about lightning is covered in the two opening chapters, followed by chapters on the Forms Taken by Lightning and Some of Its Effects, Luminous Processes Involved in the Lightning-Flash, Electrical Processes in the Lightning-Discharge, Protection Against Lightning, Electrification of Thunderclouds, and the Indirect and Distant Effects of Thunderstorms. The author is associated with the Bernard Price Institute for Geophysical Research at the University of the Witwatersrand, Johannesburg, Union of South Africa.

MILITARY AVIATION

Military Management for National Defense. John Robert Beishline. New York, Prentice-Hall, Inc., 1950. 289 pp. $5.00.

This is the first book to combine the principles of industrial management with the principles of military organization. Military management is discussed in terms of Planning, Organization, Command, and Control, including military objectives, policies, leadership, and morale. The section on organization is especially thorough. General Joseph T. McNarney contributes a foreword. Colonel Beishline is with the General Staff Corps of the U.S. Army.

NAVIGATION

ANC Landing Aids Experiment Station, Final Reports, 1949. Washington 25, D.C., U.S. Civil

SOUTH KOREA: UN wounded are loaded on a Bell H-13D helicopter near Mun-mang-ni for evacuation to a rear hospital. (Acme Photo)

Mercy HAS ROTARY WINGS

The helicopter has "come into its own" in Korea. Only the most glowing reports of achievements have been attributed to military helicopters and their crews. One of the most commendable "mercy mission" performances won the Distinguished Flying Cross for the U. S. Army's Second Helicopter Detachment on January 14, 1951.

The award was made in recognition of the successful evacuation of 23 wounded men from the battlefield to a hospital 25 miles in the rear. Using four Bell H-13D helicopters, U. S. Army pilots completed the assignment in 2½ hours. One helicopter suffered 18 bullet holes during its flights.

In addition to the Army's H-13D, Bell HTL-4s are also serving in Korea. One Marine helicopter pilot made the most of his HTL-4 by evacuating four wounded (two in the cockpit and one each in litters) on one trip.

BELL *Aircraft* CORPORATION

Pioneer of Supersonic aircraft—remote controlled flight—jet and rocket propulsion—rotary wing aircraft—fighter design, armament and construction—guided missiles.

Aeronautics Administration, Office of Aviation Information, 1951. 243 pp., illus., diagrs.

These reports cover flight operations, meteorology, electronics, airfield lighting, and fog dispersal investigations made at the station during 1949. Lists of original reports are included.

PRODUCTION

Machine Shop Methods. Lorus J. Milne. New York, Prentice-Hall, Inc., 1950. 376 pp., illus., diagrs. $5.00.

The author assumes no previous knowledge of shop techniques on the part of the reader. The use of each tool and the basic principles of its design and construction are described. Separate chapters are included on drawings and specifications, handwork related to machining, cutting speeds and finish, accuracy in machining, and materials. A bibliography of about 60 books is included. The author is associated with the University of New Hampshire.

Illustrating for Tomorrow's Production. J. Harold Farmer, Abbott J. Hoecker, and Francis F. Vavrin. New York, The Macmillan Company, 1951. 203 pp., 147 illus. $5.00.

This text was developed from the war training program of the University of Texas. The greater part of the book is devoted to the fundamentals of isometric and oblique drawing, methods of making true scale perspective drawings, exploding views, and illustrative and freehand drawing, followed by a detailed description of the steps in making a production illustration. There is a separate part on Aircraft Illustrating. Mr. Farmer is with the North Texas State College, and Mr. Hoecker and Mr. Vavrin were formerly connected with the Fort Worth Division of Consolidated Vultee Aircraft Corporation.

REFERENCE LITERATURE

DIRECTORIES

Whites Air Directory and Who's Who in New Zealand Aviation. Auckland, N.Z., Whites Aviation Publications, 1950. 178 pp. 7*s.* 6*d.*

In this, the fourth edition of a useful reference book, information is presented as of October 1, 1950, on all aspects of aviation in New Zealand and in the South Pacific. The directory information is comprehensive, including military, civil, commercial, and educational fields; airports; organizations; registered aircraft; and licensed pilots.

YEARBOOKS

Jane's All The World's Aircraft, 1950-51. Compiled and Edited by Leonard Bridgman. London, Sampson Low, Marston & Company, Ltd.; New York, McGraw-Hill Book Company, Inc., 1951. 462 pp., illus. $20.

In this year's volume of this indispensable reference book, the United States leads in the number and variety of aircraft described, with 95 pages and 222 illustrations. Great Britain is next, with 84 pages and 189 illustrations; then comes France with 29 pages and 72 illustrations. By this measuring stick, Russia does not show up well, but the editor points out that only information confirmed at the time of publication was included on Russian aircraft. (There are 14 pages on Russian aircraft.) A pictorial supplement on new British aircraft shown at Farnborough in September, 1950, is included. There is a list of 63 first flights of aircraft from June 1, 1949 to May 31, 1950, of which over half were jet types.

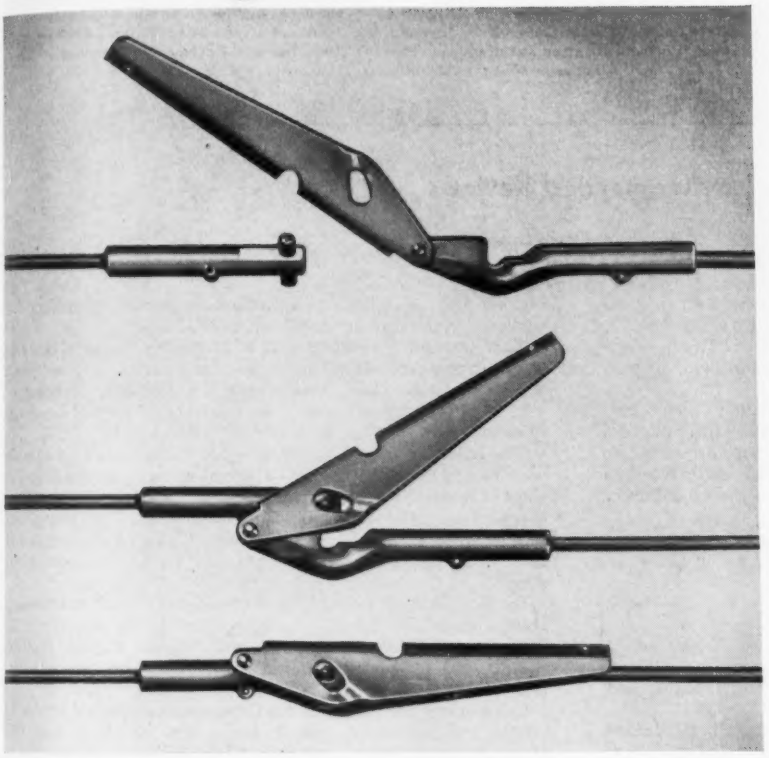
SCIENCES, GENERAL

MATHEMATICS

Elementary Theory of Equations. Samuel Borofsky. New York, The Macmillan Company, 1951. 302 pp. $4.25.

The author's aim is to present facts concerning the roots of algebraic equations and methods for obtaining them and to introduce some concepts of modern algebra. The concepts of field and polynomial over a field are used throughout, fields being limited to those that are subfields of the com-

Pacific SCIENTIFIC NEWS



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No tools are necessary to adjust the tension, the handle serving as an ideal method of turning the barrel for adjustment.

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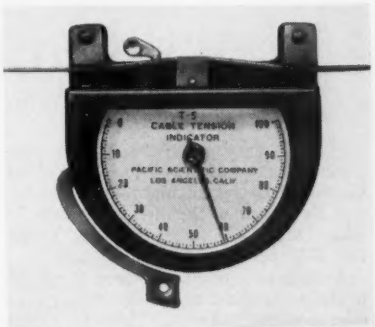
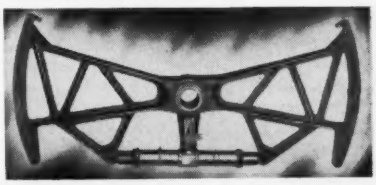


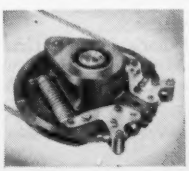
Compact, sturdy construction, combined with one-hand operation makes this the ideal instrument for testing control cable tension. Built-in indicator lock permits accurate reading after removal from areas where dial cannot be seen. The Sturgess Tensiometer dial indicator requires no zero resetting.

Accurate readings are recorded on cables rigged as low as 15 pounds with the model illustrated. Other models are available for readings on cables requiring extreme high tension. Each instrument is packed in a sturdy hardwood case for protection.

THE NEW LIGHT-WEIGHT CONTROL CABLE REGULATOR INSURES CONSTANT CABLE TENSION UNDER ALL FLIGHT CONDITIONS



This is the new R-80 Quadrant, built-in type regulator, used in one of our most famous bombers. Light-weight, sturdy, entirely mechanical in operation, built to last as long as any other structural part. This type regulator is particularly valuable in large transports or bomber-type planes where extreme structural flex takes place. This control cable regulator provides correct control-cable tension under all flight conditions.



For fighter-type planes this model, R-81, actuated arm, sliding cable construction is ideal for control systems with high-design loads. Mechanical in operation, this simple, rugged, built-in regulator is ideal for small space.

plex number system. No calculus is required of the student. The author is associated with Brooklyn College.

PHYSICS

Superfluids. Volume I, Macroscopic Theory of Superconductivity. Fritz London. New York, John Wiley & Sons, Inc., 1950. 161 pp., diagrs. $5.00.

Dr. London presents the electrodynamic theory of conductivity, which he developed with his brother in 1934, interpreting the experimental results from a single macroscopic point of view. The low-temperature transfer mechanisms of superfluid helium and of the superconductors are considered as pure quantum mechanisms. A program for the future molecular theory as drawn from the macroscopic electrodynamics of the superconductor is presented with the aim of eventually reaching an electronic theory of superconductivity.

Technical Optics. Volume II. L. C. Martin. London, Sir Isaac Pitman & Sons, Ltd.; New York, Pitman Publishing Corporation, 1950. 344 pp., illus., diagrs.

This is the second volume of a revised and enlarged edition of the author's *Introduction to Applied Optics*, originally published in two volumes in 1932. The present volume deals with such new advances as phase-contrast microscopy, Schmidt cameras, and aspheric surface optics and covers, particularly optical instruments. The telescope, microscope, binocular instruments, photographic lenses, image projection, and instrument testing are among the subjects discussed. Lists of references are given at the ends of chapters. The author is Professor of Technical Optics at the Imperial College of Science and Technology in London.

STRUCTURES

Mechanics of Materials. Harry D. Conway. New York, Prentice-Hall, Inc., 1950. 325 pp., diagrs. $6.35.

In this textbook for engineering students, emphasis is placed on the assumptions on which theories are based, and numerous illustrative examples are included as an aid to the student in applying formulas to practical problems. A separate chapter introduces the subject of Thick Cylindrical and Spherical Shells toward the end of the book, and there is an appendix on Moments of Inertia of Areas. The author is a Professor in the Department of Engineering Mechanics at Cornell University.

Aeronautical Reviews

(*Continued from page 90*)

passages is turbulent. The results of computations for heat exchangers with rectangular and triangular passages are plotted.

A New Form of Solution of Hermite's Equation. W. A. Mersman. *Journal of Mathematics and Physics*, Vol. 29, No. 3, October, 1950, pp. 191–197. 4 references.

A study of a modified form of Hermite's equation which occurs in the study of the laminar boundary layer of a compressible fluid over a heated flat plate to obtain a solution that is tractable to numerical methods of computation. The method is applicable to any linear homogeneous differential equation of the second order to obtain a second solution when one is already known.

Water-Borne Aircraft (21)

Design of Seaplane Hulls. John D. Pierson. *Interavia*, Vol. 5, No. 11, November, 1950, pp. 583–585, illus.

A method for the estimation of hull proportions, based upon a consideration of the basic flow conditions during take-off and landing, aerodynamic and hydrodynamic factors, weight, and balance.

Stability Tests on a Large Scale Model of the Shetland Hull Bottom. H. G. White and A. G. Smith. *Gt. Brit., Aeronautical Research Council, Current Papers No. 27*, 1950 (January 16, 1943). 21 pp., illus. 5 references. British Information Services, New York. $0.50.

Wind Tunnels & Research Facilities

The Use of Interferometers in Aerodynamics at the L.F.A. Brunswick, Germany. S. P. Hutton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2366*, 1950 (July, 1946). 42 pp., illus. 19 references. British Information Services, New York. $1.90. Brief record of the work done under Dr. Zobel at the Luftfahrtforschunganstalt Hermann Göring on the theory, design, and development of Mach-Zehnder interferometers.

The Use of a Luminescent Lacquer for the Visual Indication of Boundary-Layer Transition. Jackson R. Stalder and Ellis G. Slack. *U.S., N.A.C.A., Technical Note No. 2263*, January, 1951. 17 pp., illus. 5 references.

Visual determination of the boundary-layer transition point is achieved by means of a phosphor pigment mixed with a lacquer, which fluoresces with a bright yellow color under irradiation by ultraviolet light when dry and exhibits no fluorescence when wet.

The Interaction Between an Oblique Shock-Wave and a Turbulent Boundary-Layer. O. Bardsley and W. A. Mair. *Philosophical Magazine*, Vol. 42 (7th Series), No. 324, January, 1951, pp. 29–36, illus. 4 references.

Experiments were made in an intermittent supersonic wind tunnel at $M = 1.965$ using a double-wedge airfoil. Schlieren photographs were made to show the reflection of oblique shock waves of different strengths at the turbulent boundary layer on the tunnel wall; the shock strength was varied by changing the incidence of the model. Descriptions of the wind tunnel and the schlieren apparatus are included.

Experimental Investigation of a Stationary Cascade of Aerodynamic Profiles. William T. Sawyer. *Zurich, Eidgenössische Technische Hochschule, Institut für Aerodynamik, Mitteilungen Nr. 17*, 1949. 78 pp., illus. 46 references. Verlan Leemann, Zurich. Sw. Fr. 12.–. In English.

The effects of Reynolds Number and turbulence on a cascade were measured at low speed. The cascade was designed on the basis of Ackeret's continuum theory. Steps in the design of the cascade and in the testing and calibration of the wind tunnel and its instruments and balances are explained. Two-dimensional and three-dimensional tests were made, and tests results compared with theory and verified the accuracy of Ackeret's theory.

Camber Derivatives and Two-Dimensional Tunnel Interference at Maximum Lift. R. C. Pankhurst and H. H. Pearcey. *Gt. Brit., Aeronautical Research Council, Current Papers No. 28*, April 19, 1950. 5 pp. 2 references. British Information Services, New York. $0.25.

Calculations are presented for the corrections for aerodynamic camber and mid-chord upwash due to the lift effect in a rectangular closed-throat wind tunnel (two-dimensional flow).

Colorado University's Steam-Jet-Powered Supersonic Wind Tunnel. *Aeronautical Engineering Review*, Vol. 10, No. 3, March, 1951, pp. 38, 39, 108, illus.

New Acoustical Plan Kills Tunnel Noise. *Aviation Week*, Vol. 54, No. 3, January 15, 1951, pp. 29–31, illus. Low-frequency high-intensity noise is muffled effectively at the N.A.C.A.'s Lewis Flight Propulsion Laboratory with a series of resonators, Fiberglas panels, and a trumpet diffuser.

Aeroproducts Division, General Motors Corporation, Spin Pit for Supersonic Propellers. *Shell Aviation News*, No. 150, December, 1950, p. 20, illus.

The Saab Gradient Tank; An Aid to Aeroplane Design. Lennert Stenström. *Saab Sonics*, No. 12, October–December, 1950, pp. 18–25, illus. For measuring pressure distribution on three-dimensional bodies.

New Development Center Facilitates Aircraft Research. F. O. Carroll. *SAE Journal*, Vol. 59, No. 1, January, 1951, pp. 50–53, illus. (Excerpts from a paper: The Arnold Engineering Development Center.)

Italian Test-House; Fiat Plant for Experimental and Development Tests of Turbojet Units. *Flight*, Vol. 58, No. 2188, December 28, 1950, p. 626, illus.

Influence of Reynolds Number on the Separation (Cavitation) Flow. V. A. Konstantinov. (*Akademiia Nauk S.S.S.R., Leningrad, Otdelenie Tekhnicheskikh Nauk, Izvestiia*, 1946, No. 10, pp. 1355–1373.) *U.S., Navy Department, David W. Taylor Model Basin, Translation No. 233*, November, 1950. 20 pp., illus.

A preliminary, qualitative study. Six circular cylinders of 5-, 10-, 20-, 30-, 40-, and 50-mm. diameter were tested in the cavitation tunnel, and test results were analyzed. A short description of the water tunnel and experimental methods is given.

Boeing Aerial Tanker delivers fuel twice as fast with weight saving of 550 lb.

•

Uses New Refueling Pump driven by VICKERS HYDRAULIC MOTOR

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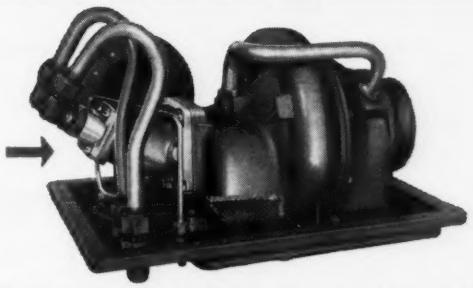

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R. D. Gilson

(*Continued from page 20*)

tural design of new developments of the "Flying Boxcar."

Robert Gilson had met his wife, the former Mary Ellen Calhoun, while he was at Martin and she was "completing her training at Johns Hopkins for a nursing career." Mrs. Gilson is an R.N., but she was married before she had a chance to practice. The couple, who tied the knot in 1940, are the parents of two girls—Jane, aged 8, and Sally, aged 3.

In a retrospective mood Robert Gilson writes: "Shortly after I joined the Martin Company in 1936, as an Aerodynamicist, I had a few words to say about the little data we had on landing speed of the export version of the B-10-B; so Ken Ebel asked me to come along on a test hop and get the data for myself. This was a thrilling moment for me and launched me on the flight-test end of my career. However, my inquisitiveness has also led me into stress analysis and power-plant installation work, since I seem to prefer airplanes as a whole rather than following a speciality. I have been more serious about my work at times than is necessary. The ground crew will often recall the unhappy day that I walked away from a ground-loop wreck complaining about the engine thermocouples that failed during the fuel-consumption flight test so ignominiously completed."

Mr. Gilson claims to be a "super dub at golf and bowling," but he does admit that he enjoys both games. He partakes in the latter sport as a member of the company's Engineer Ten-Pin League. He also is the holder of a Private Pilot's certificate but says that he has not used it for several years.

F. A. Cleveland

(*Continued from page 20*)

A.B. was given in 1943, and the M.A. was conferred in 1944.

Prior to joining Lockheed in June, 1946, Al Cleveland worked at the N.A.C.A. Lewis Flight Propulsion Laboratory. The major portion of his 2 years there was spent as Assistant Project Engineer on the design, development, and operation of the first two sizeable supersonic wind tunnels built there. During his last few months there he was working as Assistant Project Engineer on the design of the 6- by 8-ft. supersonic tunnel.

Employed originally by Lockheed as an Aerodynamics Engineer, Mr. Cleveland was promoted in April, 1947, to Aerodynamics Leadman, Preliminary

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Design Department, on an Air Force missile-development project. It was in this particular period that he applied for a patent on a movable turbojet afterburner flameholder to reduce the thrust loss while the afterburner is not operating. He also applied for, and received, a patent on a new-type Mach meter. He was promoted to his present position in January, 1951.

During the past year, Mr. Cleveland served as a member of the 190-cu.in.-Class Technical Committee, N.A.A. Contest Board. He and his wife, the former Fredericka Welsh Betts, thoroughly enjoy sailing and skiing when the seasons permit. They can usually be found on the summer weekends sailing at Lake Arrowhead, where Mrs. Cleveland skippers her "Flattie." Next season, they expect their little daughter, Shelley, who was born on September 15, 1950, to act as roving ballast. During the winter, Mr. and Mrs. Cleveland get in as much skiing as the snow and their time permit. Their year-round hobby, however, is building furniture, etc., in their woodworking shop; his wife is an expert on sanding and finishing. Whatever free time Mr. Cleveland has had in the last 6 months or so has been 100 per cent occupied in completing several of the subcontracting jobs on the Cleveland's new home in La Canada.

J. W. R. Drummond

(*Continued from page 20*)

with Canadian P. & W., where he has remained ever since.

Mr. Drummond lists his hobbies as skiing, tennis, and squash and is a member of the Montreal Amateur Athletic Association and the Mount Royal Tennis Club. He was married in 1946 to the former Joan Mariam Barclay.

Members on the Move

(*Continued from page 10*)

J. G. Mitchell (T.M.), Assistant to the Chief Engineer, Field Aviation Company, Ltd. Formerly, Design Draughtsman, A. V. Roe Canada Limited.

Paul E. Pedersen (T.M.), now Instructor, Stress Analysis, Design, Lofting, Aeronautical University, Chicago.

David C. Prince, Sr. (M.), Vice-President, Staff of President R. J. Cordiner, General Electric Company. Formerly, Vice-President in Charge of the General Engineering Laboratory, G-E.

Otis B. Renalds (T.M.), Stress Analyst, Lockheed Aircraft Corporation. Formerly, Graduate Student, Department of

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Section 2

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Aeronautical Engineering, New York University.

Charles Hugo Richard (T.M.), U.S. Armed Forces. Formerly, Fort Worth Division, Consolidated Vultee Aircraft Corporation.

G. Truxton Ringe (M.), Manager, Servomechanisms Section, Westinghouse Electric Corporation. Formerly, Aviation Section, Transportation Department, Westinghouse.

Robert H. Rogers (T.M.), Junior Design Engineer, Power Plant Group, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Assistant Engineer, American Airlines System.

Bernard B. Silverman (T.M.), now Draftsman, Kaman Aircraft Corporation.

Donald W. Simpkins (T.M.), Technical Illustrator, Technical Publications Department, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Template Maker, Chance Vought.

Joseph L. Sims (T.M.), Aeronautical Research Development and Design Engineer, Redstone Arsenal, Ala. Formerly, Engineer GS-5, N.A.C.A., Langley Air Force Base, Va.

Captain Harold B. Stuber (T.M.), Pepperrell Air Force Base, 6600 A.D.G., A.P.O. 862, c/o P.M., New York. Formerly, U.S.A.F Institute of Technology, Wright-Patterson Air Force Base, Ohio.

E. C. Sulzman (M.), Vice-President in Charge of Sales, Jack & Heintz Precision Industries, Inc. Formerly, Sales Manager, Wright Aeronautical Corporation.

Gordon P. Thorn (M.), Service Engineering Manager, Lockheed Aircraft Corporation, Marietta, Ga. Formerly, Flight Test Supervisor, Lockheed.

Stephen Tsoneff (M.), Chief Engineer, U.S. Propellers, Inc. Formerly, Chief Aerodynamics Engineer, Radioplane Company.

Robert G. Urquhart (M.), Senior Aerodynamic Engineer, The Glenn L. Martin Company. Formerly, Associate Professor, Aeronautical Engineering, Agricultural and Mechanical College of Texas.

William C. Volz (T.M.), now Engineer, 7 by 10 Wind-Tunnel Section, David Taylor Model Basin, Md.

Averil D. Walker (T.M.), now Junior Engineer, Boeing Airplane Company.

Louis J. Walkover (M.), Engineering Designer "A," Preliminary Design and Analysis, Aerophysics and Atomic Energy Research, North American Aviation, Inc. Formerly, Guided Missiles Division, Fairchild Engine and Airplane Corporation.

William D. Wiard (T.M.), Naval Aviation, U.S. Navy. Formerly, Aeronautical Engineer, Wright-Patterson Air Force Base, Ohio.

Neol R. Wildman (T.M.), Engineering Technician, Lockheed Aircraft Corporation. Formerly, Structural Engineer, Skyline Tower Company.

Dewey E. Wornom (T.M.), now Engineer, N.A.C.A., Langley Air Force Base, Va.

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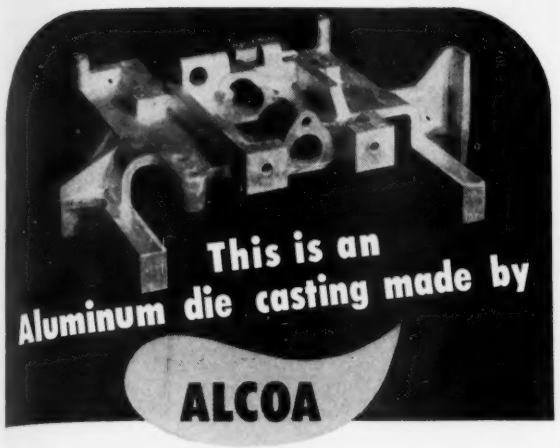

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I.A.S. Sections

Boston Section

L. J. Nuttall, *Secretary*

The December 13 meeting was held at Pierce Hall, Harvard University. The subject of the evening was "A Quick Look at the Upper Atmosphere," presented by Dr. Richard A. Craig, Research Associate, Harvard College Observatory.

Dr. Craig's talk covered atmospheric conditions up to 200 miles. He gave temperature and pressure distributions and described methods of measuring these values. Radio-wave interference and some problems encountered in rocket flights were also discussed. A question period, in which the entire audience joined, followed the talk.

Dr. Craig has degrees from Harvard and the Massachusetts Institute of Technology, and he has served with the Air Force Weather Service during World War II. He has had papers published by the National Academy of Sciences and the American Meteorological Society. His talk was well received by the I.A.S. members.

Chicago Section

A. F. Stott, *Secretary*

On January 9, 24 members and guests met for dinner in the Student Union Building, Illinois Institute of Technology.

The meeting was called to order by Chairman K. L. Burroughs at 8:15 p.m., with 45 members and guests present. Mr. Burroughs first introduced Program Chairman Robert Wendt, who briefly outlined the remaining winter and spring meetings. He then introduced Thomas B. Schillo, Group Electronics Engineer, The Glenn L. Martin Company, who spoke on "Anti-Submarine Systems." Mr. Schillo gave a historical background of detection devices and covered improvements and what is hoped for in the future. A color, sound film was shown which pictured the P5M-1 Flying Boat, the P4M-1, the XB-51, the 2-O-2A, and the Viking Rocket, as well as the launching of a rocket from the U.S.S. "Norton Sound." Some excellent shots of the launching of the Gorgon IV ram-jet rocket from the mother ship were shown. Mr. Schillo narrated this film and later held a question-and-answer session. The meeting was adjourned at 10:00 p.m.

Dayton Section

W. A. Barden, *Secretary*

One hundred and twenty-one persons attended the dinner preceding the January 18 meeting. A total of about 230, including S.A.E. members, heard the speaker of the evening, Major Gen. F. O. Carroll, present a lecture on "The Arnold Engineering Development Center." General Carroll's talk covered various aspects of the A.E.D.C., including the high-altitude engine-test facility; gas-dynamics facility; propulsion wind tunnel; central facilities; Industry and Educational Advisory Board; ARO, Inc.; and Air Research and Development.

Hampton Roads Section

George White, *Secretary*

Members of this Section at their January 15 meeting heard G. C. Shafer, Aircraft Gas Turbine Divisions, General Electric Company. The subject of his talk was "Jet Propulsion for Aircraft—Current Improvements and Plans for the Future."

Several portions of Mr. Shafer's address were supplemented by slides and motion pictures, illustrating the

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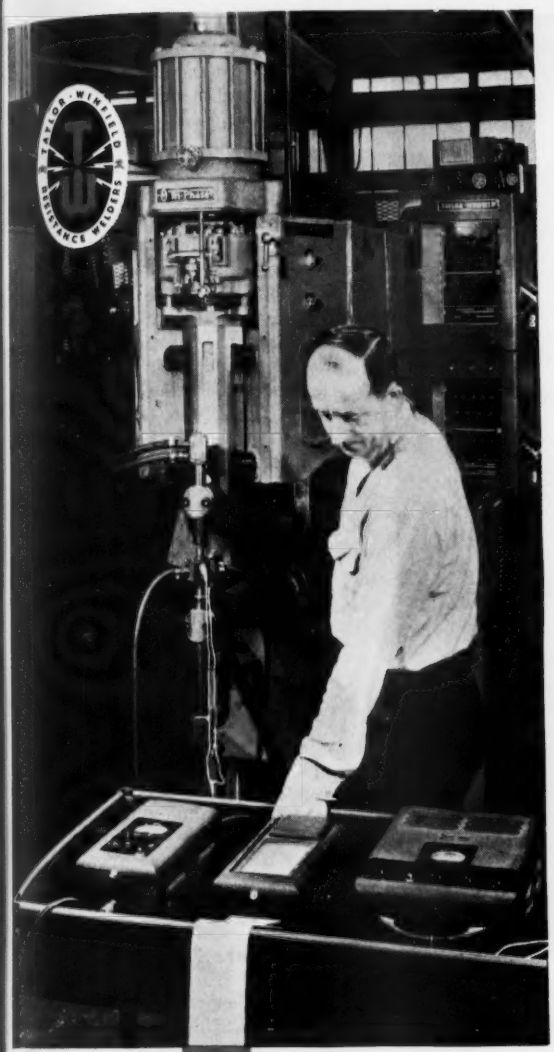

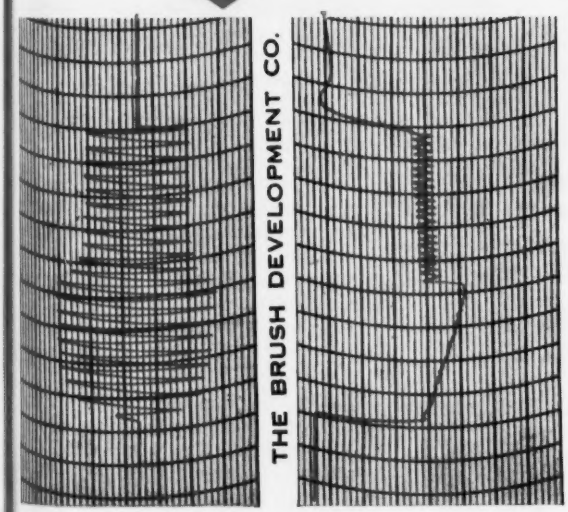

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principles of jet-engine operation and depicting the development of the jet engines from the earliest to the newest experimental models.

Of particular interest were revelations of performance and design improvements on some of the latest engines. The speaker described much of the test equipment used by General Electric and told of the difficulties that had to be overcome in the development of new experimental designs.

Because of the nature of the material presented, the meeting attendance was limited to those having Government clearance for "Restricted" information. There were approximately 250 persons present, including a large group of Langley Air Force Base personnel attending as guests of the Section.

Seattle Section

William L. Gray, *Secretary*

The Section Officers for 1951 are as follows: Chairman, Robert E. Hage; Vice-Chairman, John D. Alexander; Secretary, William L. Gray; and Treasurer, Edward A. Rock.

The January 25 dinner meeting was held at the Officers Club at the Sand Point Naval Air Station, Seattle. After cocktails and dinner had been served, the meeting was opened by the presiding officer. Three speakers, all of whom were from Boeing Airplane Company, were heard by the 150 persons attending. John E. Steiner, of the Aerodynamics Unit, spoke on "Pod vs. Submerged Engines"; Howard W. Smith, of the Structures Unit, Research Group, talked on the "Bicycle vs. Tricycle Landing Gears"; George S. Schairer, Staff Engineer, Aerodynamics and Power Plant, discussed "Turbojets vs. Turboprops."

Toronto Section

H. C. Luttman, *Secretary*

The Annual General Meeting was held on January 17, and the results of the election that had been conducted by mail were announced. Officers for the coming year are as follows: Chairman, H. C. Luttman; Vice-Chairman, C. F. Matthews; Secretary, S. L. Britton; and Treasurer, J. W. Ames. Approximately 75 persons attended the meeting.

The Chairman then gave a review of the year and the Treasurer and the Chairman of the Membership Committee submitted their reports.

At the conclusion of the business the guest speaker, C. H. "Punch" Dickens, Sales Director, de Havilland Aircraft of Canada, was introduced by R. D. Hiscocks. Mr. Dickens' subject was "Ramblings of a Bush Flyer," and his

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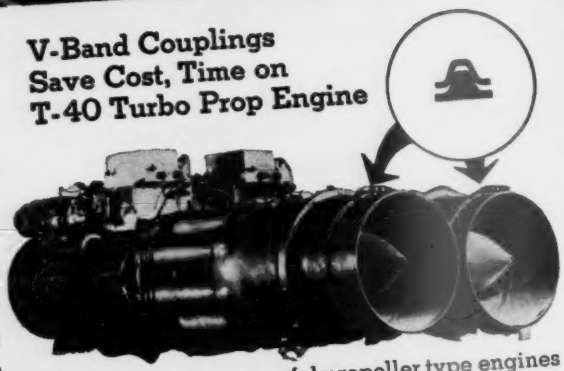

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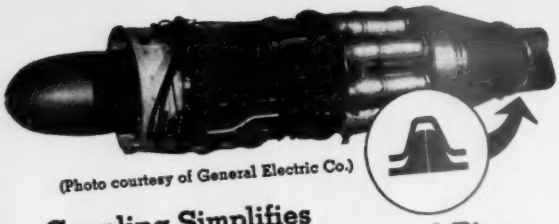
ENGINEERS' NOTEBOOK



(Photo courtesy of General Electric Co.)

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experience in this field of aviation is extensive. Mr. Dickens reviewed the development in bush flying from its inception in the winter of 1927–1928, when Western Canada Airways, with its four aircraft (two Fairchilds and two Fokkers), received a contract to fly men and equipment for the building of docks and grain elevators to Churchill from the end of the railway, which at that time had not been pushed through to that remote place. He gave a most interesting account of several of the early long pioneer flights and emphasized the extreme difficulties under which the bush pilots of those days were operating with comparatively unreliable aircraft, poor maps, no radio, and anything up to a 50° to 60° compass deviation. Gradual improvement in equipment eventually culminated in the Noorduyn Norseman, which was the first aircraft in which the bush pilot's requirements were given proper consideration, and, more recently, in the de Havilland Beaver.

At the conclusion of Mr. Dickens' paper, a film was shown outlining the history and the activities of Canadian Pacific Airlines, which was developed from an amalgamation of bush lines and which now covers the territory formerly covered by these pioneers. Mr. Dickens explained that the bush pilot is still operating, but his work now lies farther to the north, always on the fringe of organized communication. He emphasized the enormously important part that had been played by the bush pilot in the development of the natural resources of Canada.

D. H. Rogers, Chief Test Pilot, Avro Canada, thanked the speaker. Mr. Rogers' recent and well-known work on the Jetliner and Canuck provided an interesting contrast to the Fairchilds and Fokkers of the early bush pilot.

Wichita Section

Melvin H. Snyder, Jr., *Secretary*

The January 11 meeting was a joint meeting with the Wichita branch of the S.A.E. John J. Swearingen, Chief, Aero-Medical Laboratory, C.A.A., Will Rogers Field, Okla., was the speaker at the dinner meeting held at the Shirkmere Hotel.

Mr. Swearingen related some of the experiences encountered in the course of a number of the physiological experiments conducted at his laboratory. He showed a motion picture on the effect of explosive decompression on passengers in pressurized cabins. He also showed slides made in the course of experiments to determine the path through which the head of a passenger or pilot would move in case of a sudden deceleration, as in the case of a crash.

•A famous general of the U.S. armed services recently said, "When an airplane is sitting on the ground, it's going to waste."

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During the question period, which was one of the longest in any Institute meeting here this year, Mr. Swearingen cited experiences obtained at the Aero-Medical Laboratory and at the Navy Flight Laboratory. Mr. Swearingen's main theme was that private and commercial flight problems were different from those of the military services, because all types of persons are carried in commercial aircraft. The military services are concerned only with the effect of various flight maneuvers and experiences on physically qualified personnel, whereas the air-line passengers range from infants in arms to old people. For this reason, Mr. Swearingen stated that many safety devices that are being developed by the military, such as helmets, G-suits, and oxygen masks, are unsuitable for the use of air-line passengers. His laboratory is conducting research that will make survival of untrained persons possible in the case of emergencies. Some of the devices that he recommended are shoulder harness and reverse seating.

Student Branches

University of Alabama

Chairman Paul L. Deimling opened the January 11 meeting at which the following officers were elected for the second semester: Chairman, Major M. D. Marks, U.S.A.F.; Vice-Chairman, William O. Armstrong; Secretary, Norman L. Turnbull; and Treasurer, James P. Shivers. Thirty persons were present.

On January 23, Harold H. Warden, General Sales Manager, Propeller Division, Curtiss-Wright Corporation, spoke on "Sales Engineering." Chairman Deimling presided; 40 persons attended.

Cal-Aero Technical Institute

Joseph Baldeschi, Mathematician "A," Marquardt Aircraft Company, was the speaker at the December 14 meeting. Mr. Baldeschi, a Cal-Aero graduate, discussed "The Essential Qualities for Success." Chairman William Lee conducted the meeting; 40 persons attended.

University of Cincinnati

The January 12 meeting was called to order by Chairman Dale H. Whitford. An election of officers for the next two terms was held with the following results: Chairman, Dale H. Whitford; Vice-Chairman, Oscar Dillon; Secretary, Dale A. Benethum; and Treasurer, Joseph N. Bond. Thirty-five persons attended.

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wear rings	direct-acting pump liners

Mechanical Properties of "S" Monel*

(Age-hardened)

Yield Point	80-115,000 psi
Tensile Strength	120-145,000 psi
Elongation in 2-in.	4-1%
Hardness (Brinell)	300-375
Coefficient of Thermal Expansion (32°-212°F.) in./in/°F.	.0000068

Hardness of "S" Monel at Elevated Temperatures*

(As-cast condition)

Temperature, °F.	Brinell Hardness
Room	321
700	321
800	311
900	311
1000	321
1050	335
1100	293

*Average properties—not to be used for specification.

Hardness: "S" Monel can be age-hardened to 300-375 Brinell. It retains this hardness even at elevated temperatures. (See table.)

Resistance to Galling: "S" Monel is superior to most other hard metals in its ability to resist galling under severe conditions of pressure and friction. Often where lubrication is poor or absent entirely, "S" Monel has shown unusual resistance to seizing.

Corrosion Resistance: "S" Monel is relatively unaffected by most commonly-encountered corrosives . . . reducing acids, organic acids, acid and neutral salt solutions, strong alkalies, dry gases, and most atmospheres.

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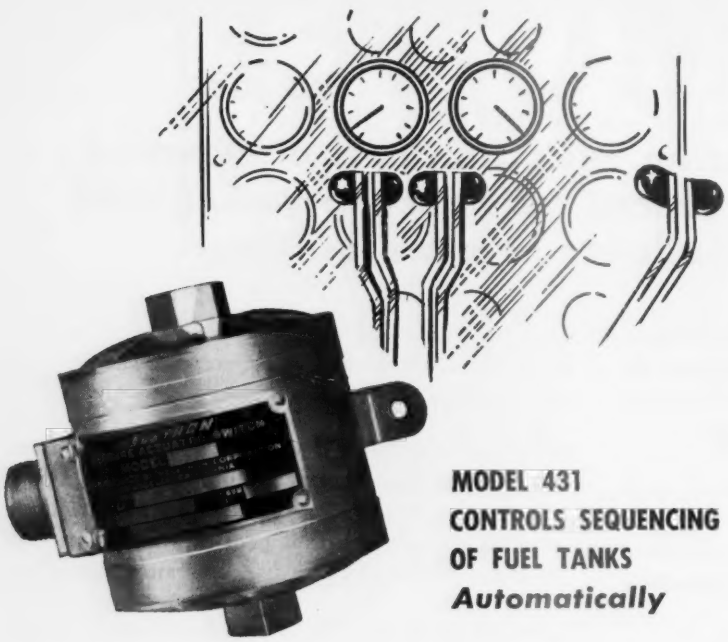

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Boone T. Guyton, Chief Test Pilot, Military Liaison, Chance Vought Aircraft Division, United Aircraft Corporation, spoke on January 15. Mr. Guyton's talk was divided into two parts; the first was on the characteristics and development of the F7U-1 Cutlass, and the second was on the industrial move made by Chance Vought from Stratford, Conn., to Dallas, Tex. A film showing the F7U-1 Cutlass was presented in connection with the talk. Chairman Whitford presided; 60 persons attended.

Clarkson College of Technology

Chairman Robert C. Waters opened the January 17 meeting at which Yih Chang Yang, Mechanical Engineering Instructor at Clarkson, spoke on the construction of a water table to simulate air action at supersonic speeds by using water at slow speeds through dynamic similarity. Two films from the Kendall Refining Company were shown, *Get the Lubrication and You Get the Service* and *Nature Plays Favorites*. A third film, *Pylon Dusters*, depicted the 1948 National Air Races. Twenty-four persons attended.

University of Colorado

The December 5 meeting was called to order by Chairman Myron J. Miller. The speaker of the evening, Prof. H. B. Siebert, Aeronautical Engineering Department, University of Colorado, discussed problems encountered while in charge of the high-speed aerodynamic section at Wright Field during World War II. Twenty-two persons were present.

On January 18, Lieutenant Commander Morris, Lieutenant Renfro, and Lieutenant Shatfield attached to the Naval Air Station, Denver, Colo., discussed naval aviation and its future Two Navy films, *Brought to Action* and *The Fleet That Came To Stay*, were shown.

Cornell University

On February 6, four staff members of Cornell's Graduate School of Aeronautical Engineering presented brief résumés of various papers that had been presented at the I.A.S. Nineteenth Annual Meeting. Professor A. Kantrowitz covered fluid mechanics; Prof. Y.-H. Kuo, supersonic, aerodynamics, and ballistic studies; Prof. C. Riparbelli, aircraft structures; and Dr. W. R. Sears, gas turbines and aerodynamics.

University of Detroit

Charles Gadd, Senior Project Engineer, Research Division, General Motors Corporation, presented a talk at the

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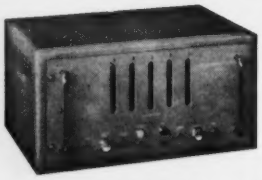

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- FREQUENCY MEASUREMENTS
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- PRECISE LOW-FREQUENCY MEASUREMENTS
- HIGH SPEED COUNTING

THE BERKELEY TIME INTERVAL METER*, Model 510, provides a direct reading of elapsed time between any two events in the range of 0.000010 to 1.0000 seconds. Accuracy of measurement is ± 10 u/secs. Any occurrences that can be translated into changing voltages may be timed. Timing may be started and stopped by independent voltages. The polarity of these control voltages may be selected by means of toggle switches so that the unit may be started and stopped by either positive or negative pulses. A sensitivity control permits selection of the amplitude of the start or stop voltages at optimum level for elimination of interference.

OPERATION: By use of photocell attachments the interval between two separate light flashes may be timed. Similarly by use of an added photochannel and a single photocell duration of a light period or a dark period may be determined.

MODIFICATIONS: Standard modifications available: addition of a photocell channel; the addition of a mechanical register to extend range to 10 seconds; threshhold control to permit selection of precise amplitude of input pulse so unit may be made to operate at any desired position on sine wave; panel switch to permit use as straight counter.

DIRECT READING: The only truly direct reading equipment of its kind, presenting results in decimal form on an illuminated panel. No interpolation, no lights to add. A convenience in the laboratory; a necessity in production.

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January 10 meeting on the subject, "Experimental Stress Analysis." A film, *Oil Films in Action*, was shown through the courtesy of General Motors' Research Division.

University of Florida

Chairman Costa Francisco presided at the January 10 meeting, which was attended by 40 persons. A film, *Target—Peace*, released through Consolidated Vultee Aircraft Corporation, was shown.

University of Michigan

The officers elected at the September 27 meeting were: Chairman, William E. Diener; Vice-Chairman, Gerald Vroman; Secretary, Jess Nourse; and Treasurer, Sydney Shrage.

At the October 11 meeting, Prof. W. C. Nelson gave an illustrated discussion of his tour of the aeronautical educational centers in Europe.

Richard Morrison, Aeronautical Research Center, University of Michigan, spoke at the November 1 meeting on Propulsion Research Problems.

On November 30, twenty members joined the Detroit Section in a meeting featuring Major Jones, who spoke on the operational characteristics of the F-86.

On December 7, Prof. Paul Chenea and Harold Allen, University of Michigan, discussed "New Structural Design Problems Resulting from Supersonic Speeds."

A field trip, including a daytime tour of the Lewis Flight Propulsion Laboratory, N.A.C.A., and an evening I.A.S. banquet with Dr. William Bollay presenting the Fourteenth Wright Brothers Lecture, occurred on December 19 in Cleveland.

On January 13, the annual banquet was complemented by a dance, held at the Flight Room, Willow Run Airport. Forty-five couples were served air-line-style dinners, after which Col. Frank Seiler, Chief, Office of Air Research, Air Materiel Command, spoke on "Large-Scale Computing Machines in the Air Force."

University of Minnesota

John Rudolf spoke on the "Automatic Control of Aircraft" at the October 31 meeting. A film, *The C-1 Auto Pilot*, was shown to the 58 persons assembled. Chairman James P. Lindberg led the meeting.

The 60 persons attending the November 21 meeting heard Stanley A. Lafavor, Aeronautical Engineer, McDonnell Aircraft Corporation. After Mr. Lafavor delivered his talk on "The History and Projects of McDonnell Aircraft Corporation," two films on *The XFH* and *The XF88* were shown. Chairman Lindberg presided.

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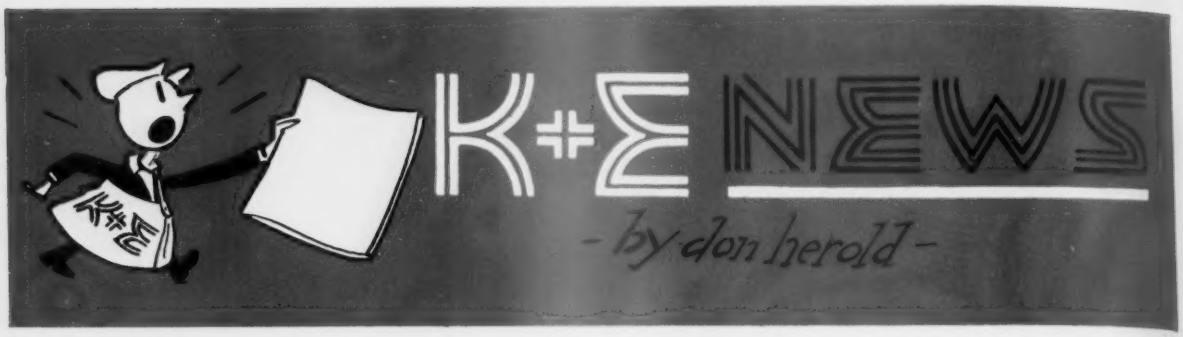

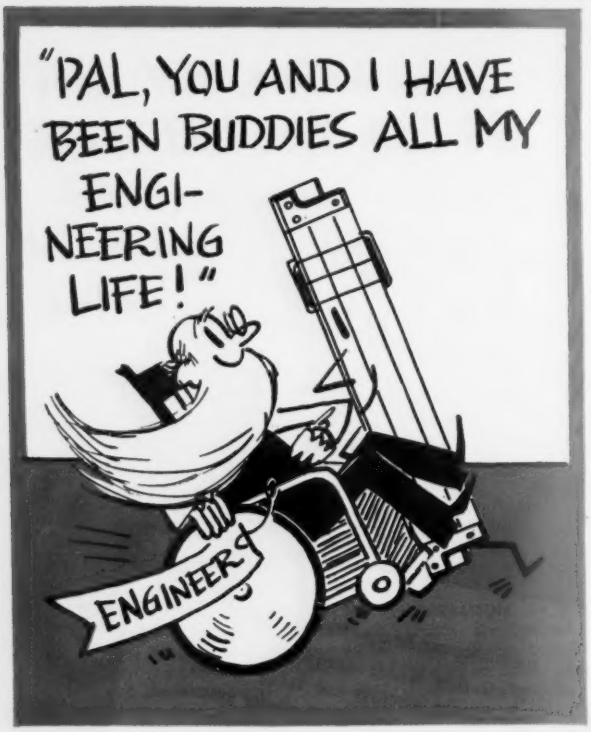

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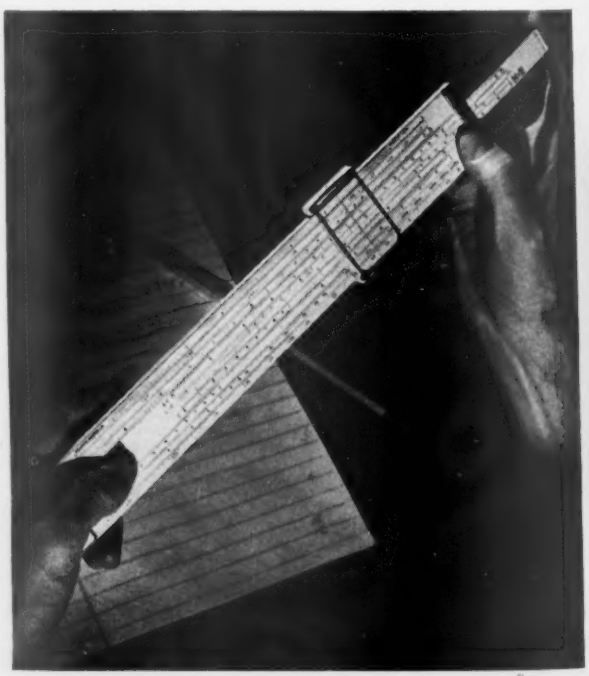

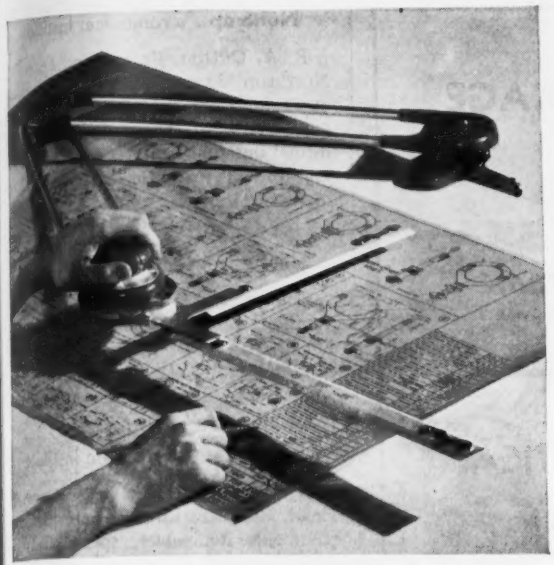

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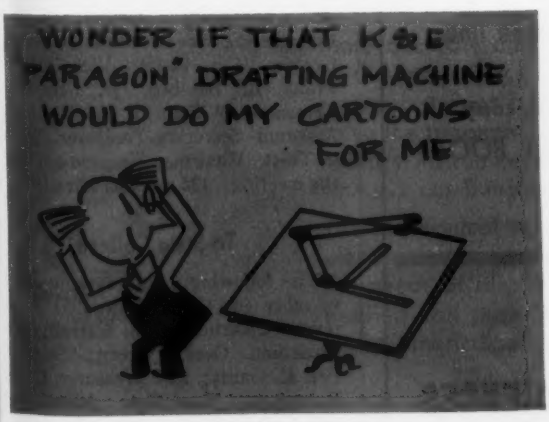

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Northrop Aeronautical Institute

R. A. Dutton, Engineering Director, Northrop Aircraft, Inc., was the speaker at a round-table discussion meeting held on January 25. The meeting was an informal one for the purpose of acquainting students with the current employment situation.

The Ohio State University

Chairman Lee Van Gossick presided at the January 23 meeting at which films, *History of United States Naval Aviation* and *Operations Crossroads*, were shown. Forty persons attended.

Rensselaer Polytechnic Institute

Professor A. J. Fairbanks, Associate Head, Aeronautical Engineering Department, Rensselaer, spoke on "The I.A.S. and Its Functions" at the September 20 meeting. Chairman Duncan W. Simpson presided; 75 persons attended.

Chairman Simpson opened the October 18 meeting, at which 145 persons were in attendance. Dr. H. H. Kurzweg, Head, Naval Aeroballistics Laboratory, Silver Spring, Md., spoke on "Problems in Supersonic Research." A film, *The University of Michigan Wind Tunnel*, was shown.

The 100 persons in attendance at the November 15 meeting heard Robert Liddell, Group Leader on Stability and Control, Republic Aviation Corporation, speak on "Some Notes on High-Speed Airplane Characteristics." Chairman Simpson presided.

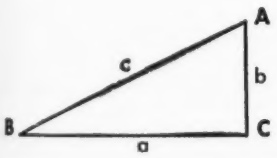
On December 13, Warren J. Allen, Project Engineer, Grumman Aircraft Engineering Corporation, spoke on "An Aeronautical Engineer's Problems in the Design of New Carrier-Based Aircraft." A film entitled *Flight Operations on an Aircraft Carrier* supplemented his talk. The results of elections held during this meeting were as follows: Chairman, George C. Gatje; Vice-Chairman, Frank L. Batchen, Jr.; Secretary-Treasurer, William F. McNeel; and Assistant Secretary-Treasurer, Warren C. Trott. Chairman Simpson conducted the meeting; 135 persons attended.

Tri-State College

The following members were elected to office for the present 1951 Winter term: Chairman, Don Carroll; Vice-Chairman, Gerald Green; Secretary, Ben K. Gantt; and Treasurer, Charles Robertson. Two films, *Attitude Gyro* and *Jato Flight Tests*, were shown.

An Aluminum Company of America film, *Unfinished Rainbows*, was shown at the January 18 meeting, at which Chairman Don M. Carroll presided. Twenty persons attended.

Arma Electrical Resolver



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The mechanical resolvers of World War II have since given way to the electrical. Application of the new miniature Arma electrical resolvers to the needs of all the Services is widening as rapidly as accelerated engineering can push it. This is another way Arma engineers work to help make America safe against those who wish to destroy it.

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Three films were presented at the January 25 meeting. They included *Of Men and Wings* from United Air Lines, Inc.; *High-Speed Refueling* from Shell Oil Company; and *The Third Pillar*, a Middletown Air Materiel Area release. Twenty-four persons attended.

U.S.A.F. Institute of Technology

This Branch attended the January 18 meeting of the Dayton Section at which Major Gen. F. O. Carroll spoke on "The Arnold Engineering Development Center." Approximately 80 members attended.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to MEMBER Grade

Cane, Eric George, B.A., Experimental Officer, Royal Aircraft Establishment.

Cooley, John L., B.S., Vice-President, California Research Corp.

Dreves, Robert G., Head, Program Planning Branch, Special Devices Center, Office of Naval Research (Port Washington).

Drummond, John W. R., B.Sc., Sales-Engineering Supervisor, Canadian Pratt and Whitney Aircraft Co., Ltd.

Eschborn, Ralph J., B.S. in M.E., Aero. Research Scientist, Lewis Flight Propulsion Research Lab., N.A.C.A. (Cleveland).

Perez-Marin, Antonio, A.E., Prof. Escuela Ingenieros Aero., Integral y Ecuaciones diferenciale; Sec. Gen. Tecnico del I.N.T.A., Instituto Nacional de Tecnica Aero.

Worman, John G., Lead Engineer—Designer, The Glenn L. Martin Co.

Transferred to MEMBER Grade

Belsky, Fred J., M. of Ae.E., Aero. Engineer, Special Devices Center, Office of Naval Research, Dept. of the Navy (Port Washington).

Thompson, William E., M.S. in Engineering, Instructor in Mechanical Engineering, Illinois Institute of Technology.

Elected to Technical Member Grade

Brenner, Claude W., S.M., Engineer, Aero-Elastic and Research Lab., Massachusetts Institute of Technology.

Cohen, Hirsh G., Ph.D. (Appl. Math.), Asst. Prof. of Engineering Research, Ordnance Research Lab., The Pennsylvania State College.

Moore, Ernest S., Design Engineer, National Research Council (Ottawa).

Stenning, Alan H., B.Sc., Research Asst., Gas Turbine Lab., Massachusetts Institute of Technology.

Transferred to Technical Member Grade

Bailey, Clay C., Jr. Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Barthelme, Richard W., Sr. Draftsman, Goodyear Aircraft Corp.

Bellman, Arthur B., B.S.Ae.E., Capt., Pilot & Technical Inspector, U.S.A.F.

Benson, Allen M., B.S.Ae.E., Chief Electronics Technician, U.S.N.

Burch, John L., B.S., Jr. Aerodynamics Engineer, Hydrodynamics Section, The Glenn L. Martin Co.

Buxton, Elliott R., B.S.M.E., Research Analyst, North American Aviation, Inc.

Carmichael, Richard F., Weight Analyst, Northrop Aircraft, Inc.

Cavalcanti, Paulo J. J., Maintenance Engineer, Vasp Airline (Brazil).

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review.* Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review,* 2 East 64th Street, New York 21, N.Y.

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Selan, Ralph, B.S. in Ae.E., Aero. Research Scientist, Ames Aero. Lab., N.A.C.A.

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Aircraft Dynamics Engineers—For research work in the fields of: subsonic and supersonic flutter, vibration, dynamic loads; stability and control of missiles; and helicopter dynamic problems. Applicants must have good background in fundamentals of applied mechanics and mathematics. Advanced degree or previous experience in field is preferred. Salaries commensurate with training and experience. Cornell Aeronautical Laboratory, Inc., Employment Office, 4455 Genesee St., Buffalo 21, N.Y.

Designer—Experienced in aircraft-engine accessories, wanted for designing lubrication system installations for jet engines. Location, State College, Pa. Salary up to $675.00 per month for fully qualified man.

ENGINEERS—The following vacancies exist in the Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

ARMAMENT: Armament Engineer (Bombing Systems) (MC1-805) ($6,400)—To conduct research and monitor projects pertaining to performance, characteristics, and overall technical capabilities of foreign aircraft bombing systems. **Armament Engineer (Bombing Systems) (MC1-806)** ($5,400)—To conduct research and accomplish projects determining the design and performance characteristics of foreign bombs, warheads and fuzes, bomb release gear, and special armament devices. **Ordnance Engineer (Aircraft Weapons and Accessories) (MC1-808)** ($4,600)—To investigate and determine the status of foreign research and development of such aircraft armament accessories as gun mounts and rocket launchers, chargers, firing devices, ammunition containers, ammunition boosters, firing circuits, heaters, cooling and scavenging devices, and link containers. **Mathematician (Ballistics) (MC1-811)** ($4,600)—To perform calculations in the solution of problems to determine terminal ballistics effects and the vulnerability of foreign aircraft and components to weapons fire. **Armament or Ordnance Engineer (Antiaircraft Artillery) (MC1-812)** ($6,400)—To conduct research and monitor projects pertaining to performance characteristics and the overall effectiveness of foreign antiaircraft artillery and unguided missiles. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

INDUSTRIAL MATERIALS: Chemical Engineer (Aircraft Materials) (MC1-813) ($5,400)—To conduct research and monitor projects relating to foreign research and development in the chemical engineering field as it relates to critical materials, such as rubber, plastics, and phenolics as used in aircraft, guided missiles, and related components. **Industrial or Production Engineer (Manufacturing Methods) (MC1-815)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aircraft industry (including air frames and missile structure) with respect to critical manufacturing methods, techniques, and assembly. **Industrial or Production Engineer (Manufacturing Methods) (MC1-816)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aircraft and missile propulsion and foreign armament industries with respect to critical manufacturing methods, techniques, and assembly. **Industrial or Production Engineer (Manufacturing Methods) (MC1-817)** ($5,400)—To conduct research and monitor projects pertaining to the status and trends of development in foreign aeronautical instrument industries such as flight instruments, automatic pilots, etc., with respect to critical manufacturing methods, techniques, and assembly. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

NUCLEAR ENERGY: Nuclear Physicist (MC1-804) ($8,800)—To supervise the Branch responsible for estimation and determination of foreign technical accomplishments and capabilities in the field of nuclear energy as they effect abilities of foreign nations to conduct air warfare. **Nuclear Physicist or Electrical Engineer (Electro-Nuclear Systems) (MC1-818)** ($5,400)—To conduct research and monitor projects pertaining to the electrical and electronic aspects of nuclear energy in its application to military purposes by foreign nations, particularly as it may affect Air Force operations. **Mechanical Engineer (Mechanical-Nuclear Systems) (MC1-819)** ($5,400)—To conduct research and monitor projects pertaining to the mechanical aspects of nuclear energy in its application to military purposes by foreign nations, particularly as it may affect Air Force operations. **Nuclear Physicist (MC1-820)** ($7,600)—To conduct research and monitor projects pertaining to the status and trends of scientific advancements by foreign countries and their technical accomplishments and capabilities in the application of nuclear energy to specific problems of air warfare. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

AIRCRAFT AND PROPULSION: Aeronautical Engineer (MC1-620) ($6,400)—To conduct research and monitor projects pertaining to performance, characteristics, and overall technical capabilities of foreign piloted aircraft. **Propulsion Engineer (Rocket Power Plants) (MC1-630)** ($6,400)—To conduct research and monitor projects relating to foreign aircraft and guided-missile rocket power plants. **Aeronautical Power-Plant, Fuel, and Lubricant Engineer (MC1-611)** ($6,400)—To supervise the group conducting research on foreign fuels, lubricants, and rocket propellants. **Aeronautical Power-Plant, Fuel, and Lubricant Engineer (MC1-618)** ($6,400)—To conduct research and estimate characteristics of foreign aircraft petroleum base or synthetic fuels and lubricants. **Aircraft Pulse and Ram-Jet Power-Plant Engineer (MC1-629)** ($6,400)—To conduct research and estimate performance of technical characteristics of foreign pulse-jet and ram-jet engines. **Aircraft Power-Plant Engineer (MC1-609)** ($7,600)—To supervise group conducting research and estimating performance and technical characteristics of foreign aircraft gas-turbine, ram-jet, pulse-jet, and rocket engines. **Aircraft Performance Engineers (MC1-622, 623, 624)** ($3,825–$5,000)—Supervise (in highest grade) and perform estimates of performance, stability and control, and other flying characteristics of foreign aircraft or guided missiles. **Aeronautical Engineers (Guided Missiles Experience) (MC1-625, 626)** ($5,400–$6,400)—To conduct research and monitor projects pertaining to performance, characteristics and overall technical capabilities of foreign guided missiles. **Aeronautical Research Engineers (MC1-614, 615, 616)** ($6,400)—To conduct research and technical analysis of foreign scientific trends and advancement in the specialized fields of the aeronautical sciences such as Structures, Dynamics (Flutter, Aeroelasticity, etc.). **Aircraft Accessories Systems Engineer (MC1-613)** ($6,400)—To conduct research and estimate performance and technical characteristics of aircraft accessories systems. **Aircraft Power Plant Engineers (MC1-632, 634)** ($4,600–$6,400)—To conduct research and estimate performance and general technical characteristics of foreign aircraft engines. **Aircraft Power-Plant Accessories and Components Engineer (MC1-631-1)** ($5,000)—To conduct research and estimate technical characteristics and performance of foreign aircraft power-plant accessories and component parts with particular reference to fuel systems, carburation and fuel injection systems, lubricating systems, ignition systems, and power-plant control systems. **Aircraft Propeller Engineer (MC1-633)** ($5,400)—To conduct research and estimate performance and technical characteristics of foreign aircraft propellers. **Aircraft Instrument and Navigational Equipment Engineer (MC1-636)** ($6,400)—To conduct research and estimate performance and technical characteristics of foreign aircraft instruments, engine instruments, automatic control equipment, and air navigation equipment. **Aircraft Mechanical Equipment Engineer (MC1-637)** ($5,400)—To conduct research and estimate performance and technical characteristics of aircraft accessories and equipment such as hydraulic systems, pneumatic systems, special escape equipment, landing gears, oxygen and pressurization systems, etc. **Aeronautical Power-Plant Research Engineer (MC1-617)** ($6,400)—To conduct research and estimate performance and general technical characteristics of foreign aircraft engines. **Aeronautical Engineer (MC1-607)** ($7,600)—To supervise the group conducting research and monitoring projects pertaining to performance, characteristics, and overall technical capabilities of foreign guided missiles. Applicants should obtain Civil Service Form 57 and mail to: Technical Analysis Division, Intelligence Department, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio (MC1ZXA).

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Rocket-Model Men—Qualified wind-tunnel and rocket-model builders and designers are needed in a long-term program of dynamic rocket-powered free-flying models and missiles, along with wind-tunnel models, subsonic and supersonic. State all qualifications in first letter. Apply to Aerolab Development Company, 1922 Lincoln Ave., Pasadena 3, Calif.

Aircraft Engineers—Excellent opening for aircraft engineers in all major fields: Designers and Draftsmen, Structures Engineers, Stress Analysts, Aerodynamicists, etc. Also openings for recent college and technological engineering graduates. Long-range military program offers unusual opportunities. Please include summary of education and experience in reply to: Engineering Personnel Office, North American Aviation, Inc., Los Angeles International Airport, Los Angeles 45, Calif.

281. Instructor—Opening in Aeronautical Engineering Department of large southeastern engineering school. Starting salary $3,074.36, plus $458.31 for summer school, if taught. B.S. in Aero. E. and M.S. in Aero. or applied mechanics required. Position to be filled before September, 1951. Send personal data, transcripts, and photograph.

280. Weight Engineer—Graduate engineer with minimum of 5 years', and preferably greater, experience. Must be thoroughly familiar with large aircraft design and weight-control procedures. Must be familiar with empirical data and formulas for preliminary design weight estimates. Supervisory experience desirable.

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285. Engineer—Professor of Aeronautical Engineering at large university desires change

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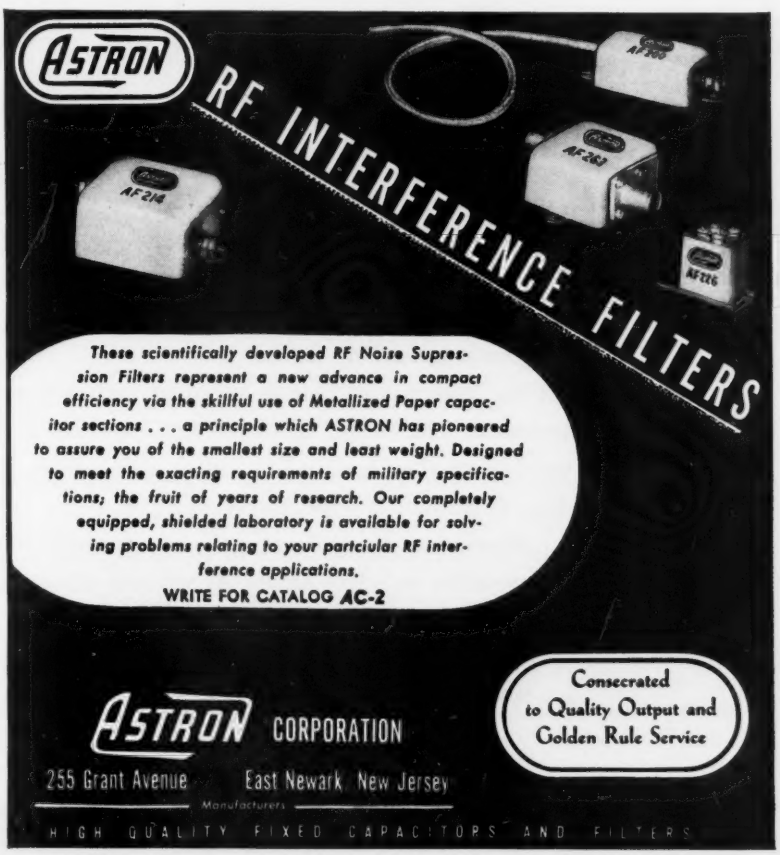
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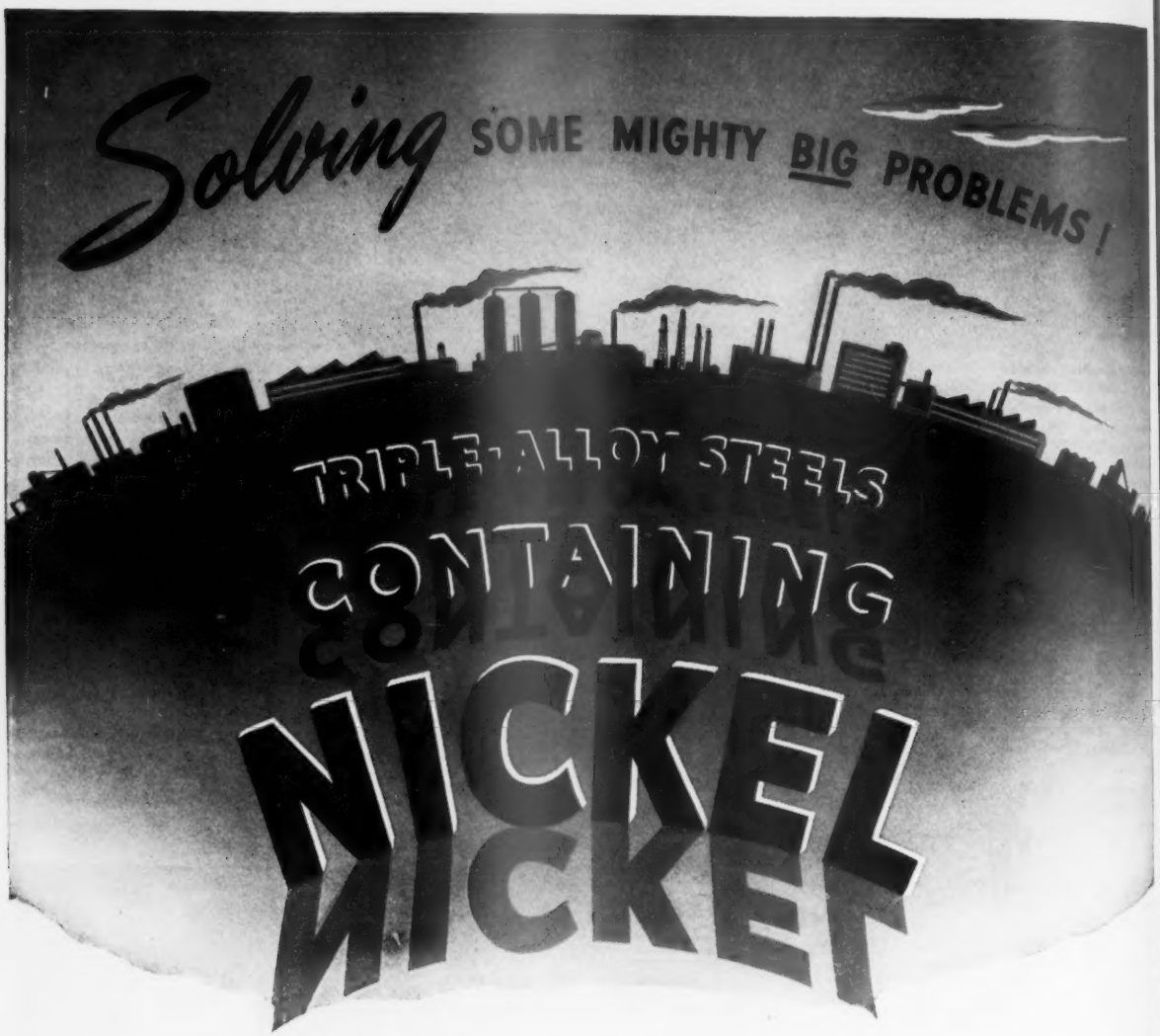

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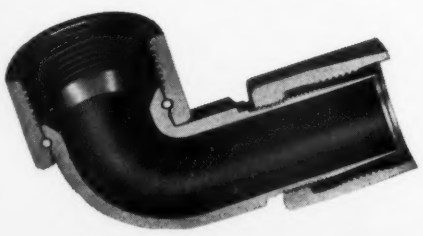

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